PRINCIPLES OF
ASSESSMENT MAPPING

LESSON IV

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<u>AERIAL PHOTOGRAPHY</u>
&
<u>OTHER AIDS TO MAPPING</u>

Ministry of Revenue
Assessment Standards Branch
1979/80

The Assessment Standards Branch wishes to acknowledge the assistance and co-operation of the Land Surveys Office, Ministry of Transportation and Communications, who supplied some of the material contained in this paper.

Part I - Principles of Aerial Photography

INTRODUCTION

The relationship between Land Surveys and Aerial Surveying has been compared to a father-son relationship. Certainly, the latter descended from the former, and has been dependent on it since early days. Even today, aerial surveying relies on land surveying for 'control points', and so, as far as our work is concerned, aerial surveying is primarily an extension of land surveying.

Mapping from ground surveys is as old as recorded history. One of the oldest surviving maps was inscribed on a Babylonian clay tablet around 2300 B.C. (One would suspect that if the draftsman could have known how long his work was going to last, he would have taken more care - a point worth pondering by the junior draftsman!)

Shortly after the invention of photography in 1839, attentio turned to the application of this technique to mapping. Early photography was, of course, dependent on balloons and even kites, but with the advent of the airplane, development was rapid. The airplane's first major role was in aerial observation and mapping during World War I, and after the war, extensive aerial surveying was carried out in Canada. During World War II, the aerial camera was vital for planning military actions, recording the results of raids and gathering intelligence information. Bombing and commando raids were invariably preceded by detailed aerial surveys, and the aerial camera is still in action today in the trouble spots of the world.

Canada has always ranked among the most advanced countries in the field of aerial surveying, and Canadian aircraft and crews may be found in South America, Asia and Africa. A great deal of aerial photography has been done in Canada in connection with highway construction, timber inventory, urban planning, and so

on. To attempt accurate mapping today, without aerial photography, could be compared to attempting to run a business office without telephones, typewriters or electric lights - that is, using 19th Century techniques!

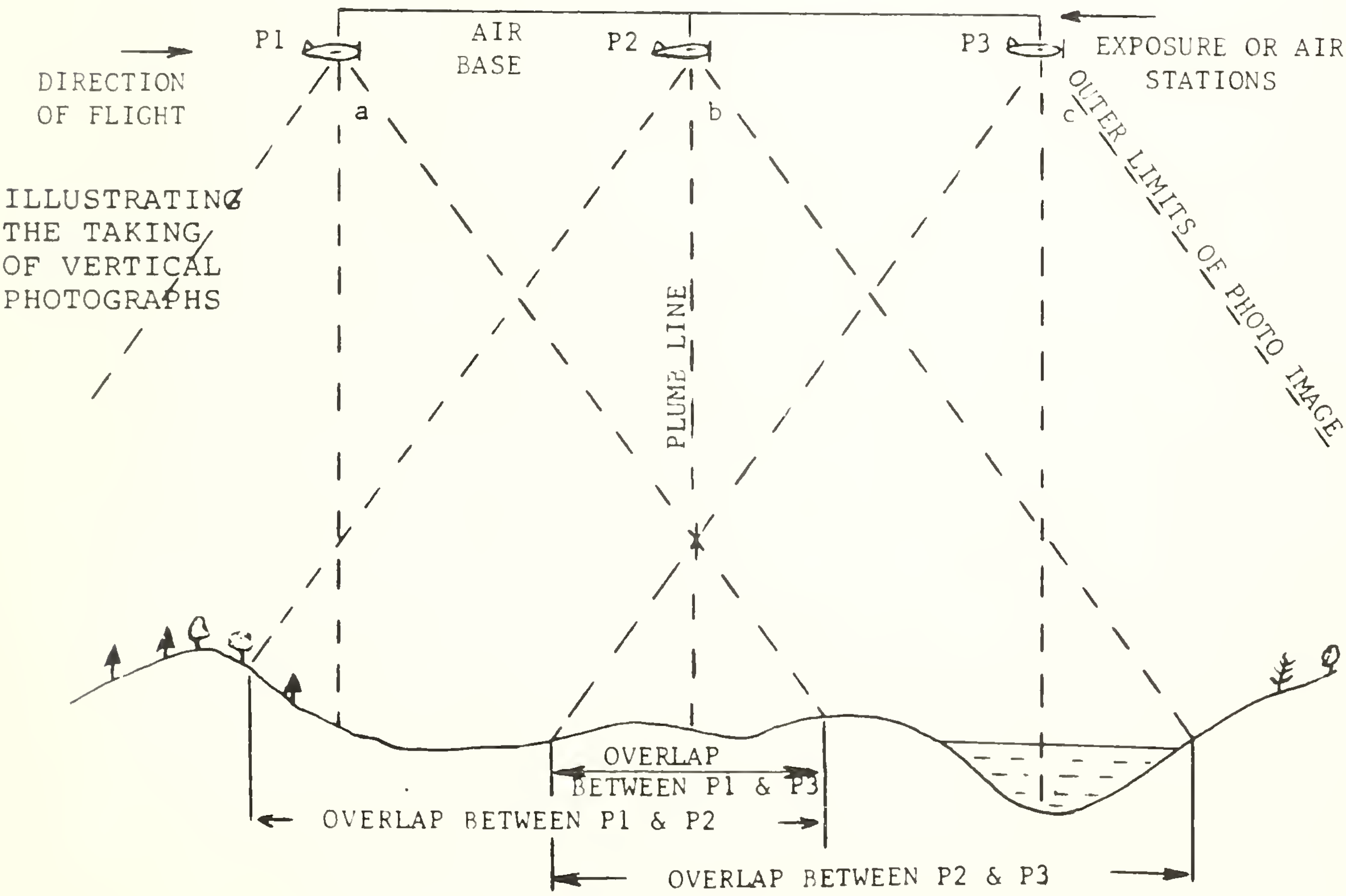
The mapping draftsman must, therefore, know something about aerial photography - its uses and its weaknesses. In this paper we will examine some facets of the subject of interest to the assessment operation.

(a) Photographic Techniques

We will be dealing only with vertical air photographs, in which the object is photographed from directly above. Oblique photographs, in which the object is taken at an angle from the vertical are of little value to the draftsman, although they may be valuable to the assessor for court exhibits and the like.

For vertical photographs, the aircraft flies in a straight line at a predetermined altitude, and the camera (mounted in the floor of the aircraft) is set to take overlapping pictures. The 'forward lap', that is, in the direction of flight should be 60%, while the 'side lap' between adjacent parallel flights should be 30%.

Figure #1



The area which an air photograph represents on the ground can be determined if one knows the scale of the photograph. The scale is simply a porportion of distances or areas between those on an air photograph and those that the photograph represents.

The determination of scale can be derived in two ways. The most common method consists of identifying two points on a photograph (e.g. road intersections) for which the ground distance is known and measuring the photo distance. The two values obtained can be expressed as a proportion which can be used as a standard conversion factor.

For example, if the distance between two cross-roads on a photograph is 1.31 inches and if this represents a known ground distance of 1,729 feet, this is a measure of the scale of the air photograph.

$$\text{Scale} = \frac{\text{Distance on air photo}}{\text{Distance on ground}}$$

$$\therefore \text{Scale} = \frac{1.31''}{1729'}$$

to simple divide by 1.31 $\therefore$ Scale = $\frac{1''}{1320'}$

$\therefore$ 1" on the photograph represents 1320 feet on the ground

On many maps such as on the topographical series, scale is represented simply as a proportion devoid of specific units. This can be applied to the above example by converting each distance to the same unit of length. By converting to inches the proportion is expressed as follows

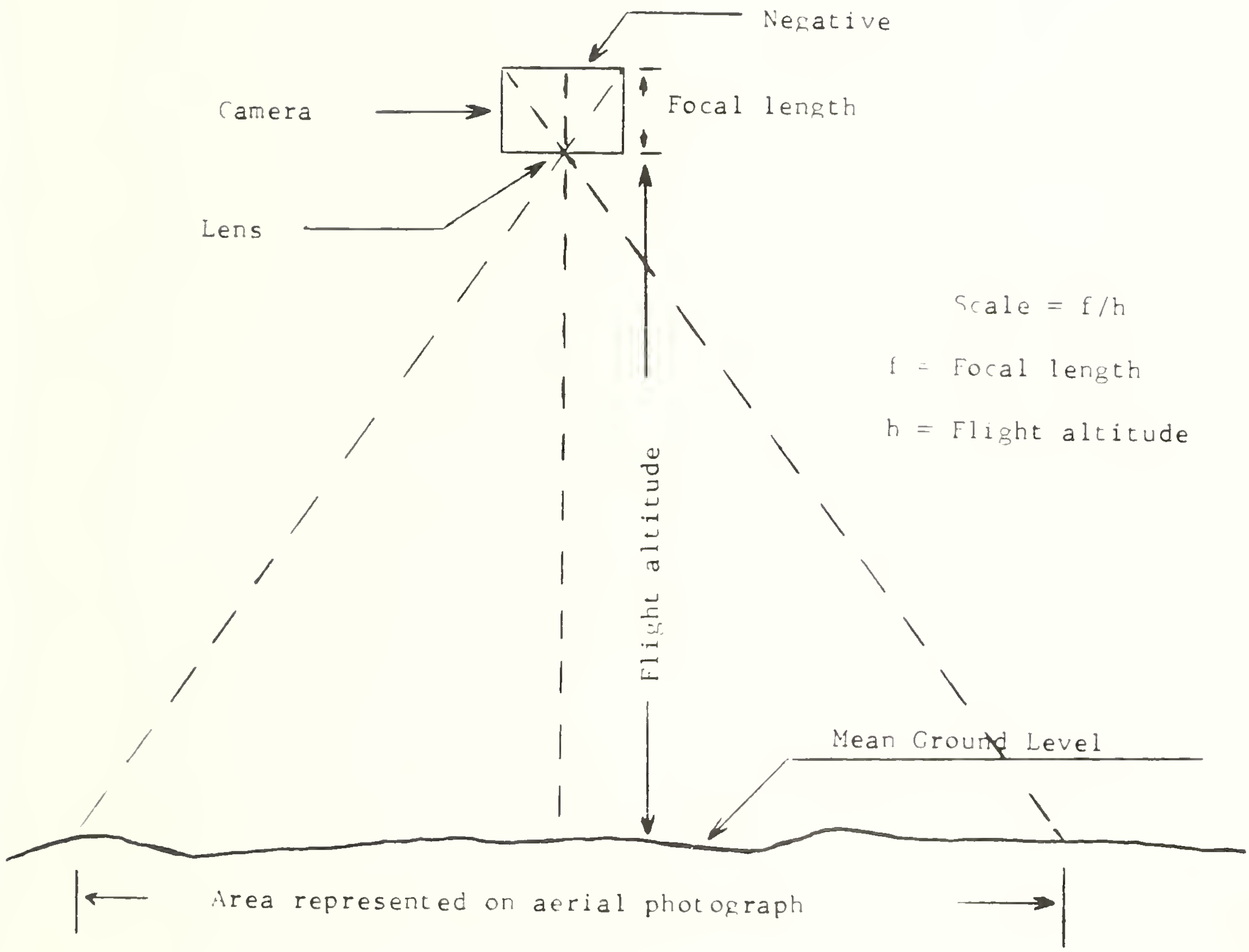
$$\begin{aligned} \text{Scale: } 1'' &= 1320' \times 12 \\ 1'' &= 15{,}840'' \end{aligned}$$

now by dividing through by inches a more universally applicable expression is obtained.

Scale 1:15,840

An additional method to calculate the scale of a photograph can be derived by using the information on Figure #2. The scale of the photograph depends on the focal length of the camera (the distance from the lens to the film) and the height of the aircraft. The focal length and altitude height is an expression of the same proportion as the distance covered on an air photograph compared to the distance it represents on the ground.

PHOTO SCALE   Fig. #2



If a photograph is taken at an altitude of 7,920 feet above the ground by a camera with a standard focal length of 6 inches, the scale of the air photograph is:

$$\text{Scale} = \frac{6''}{7920'}$$

$$\text{or} \quad \frac{1''}{1320'}$$

or 1" = 1320'

or 1" = 15,840

Scale: 1:15,840

(b) Stereoscopic Viewing

The reason for the overlap in the photographs is to permit three-dimensional study. If the customer is not interested in this, the aerial survey corporation will supply prints of alternate photographs, which still have sufficient overlap to ensure complete coverage.

Generally, in assessment mapping, three-dimensional viewing is unnecessary, since the draftsman is interested only in property lines, building locations, etc. However, there are occasions when a three-dimensional photograph is of value, especially in rugged terrain.

Everyone with normal eyesight has been employing stereoscopic vision since he began exploring his crib. However, human eyes are only about 2½ inches apart, and consequently, true stereoscopic vision exists only for a distance of about 20 - 30 feet. Beyond this, we rely on experience, relative size, speed of movements, etc., to gauge distances.

Aerial photographs have the effect of 'extending' the eye distance to the length of the air base. When two photographs are viewed through a stereoscope, each eye sees a different picture, and the result is an exaggerated three-dimensional effect - buildings appear taller, holes appear deeper, and so on. These vertical distances can be measured with a stereoplotter.

This is a sophisticated instrument in which the photographic images are projected to form a magnified three-dimensional model in the operator's field of vision. The optical sight can be moved in any direction and creates the effect of 'flying' at will over any part of the terrain covered by the two photographs. There is a floating mark, or dot, in the viewer which can be raised or lowered in the field of vision. A scale connected to this enables vertical heights to be measured and contours followed - the floating mark can be kept at ground level and moved around hills, valleys, etc.

In its simplest form, (if this term can be used), the stereoplotter is linked to a plotting arm on an adjacent drafting board, and the arm follows all movements of the optical sight through mechanical linkages. As the operator follows roads, fences, rivers, contours, etc., with the sight, the tracing arm faithfully follows every movement of the sight and produces an ink drawing of the area.

With more advanced systems, the stereoplotter is linked with a computer input system and all movements - horizontal or vertical - of the floating mark in the sight, are fed into the computer, and stored until required. The computer can then produce an ink map by controlling a tracing arm.

(c) <u>Computer Storage</u>

The 'Digital Map', in which information is recorded in a data bank rather than in 'hard copy format' (that is, map sheets) has the advantages of easy updating of information, and readily available

special purpose maps at any required scale with any desired combination of features. Remote entry systems could enable many agencies to pool their data, overcoming the present day difficulties of obtaining plans from various outside sources.

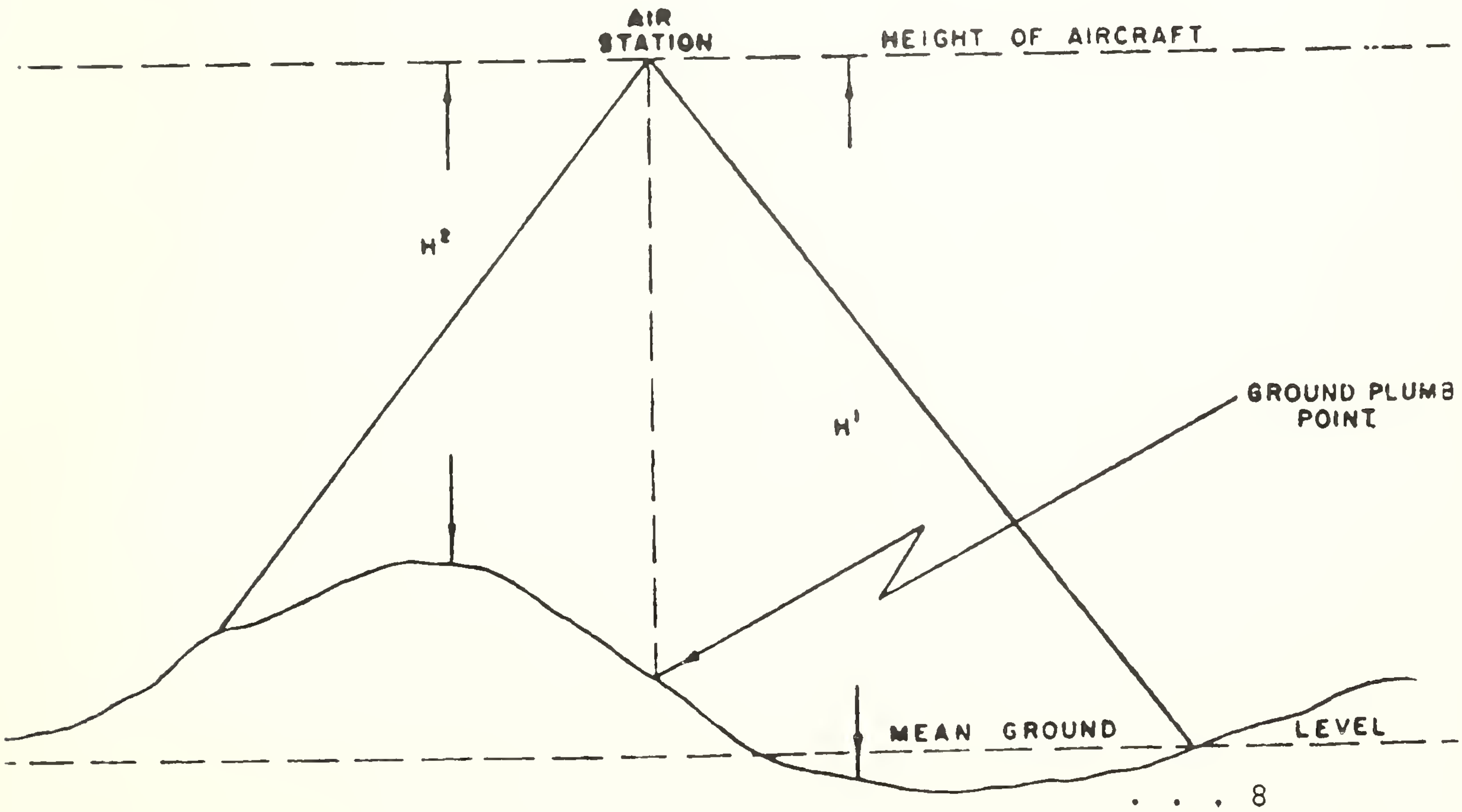
Certainly, no long range mapping programme can ignore the growing field of computer mapping. The Department of Highways is well advanced in this field and construction plans, profiles, etc., are produced in minutes, complete with meticulous lettering. Once a province-wide system of grid coordinates is adopted, the way will be open for general use of this technique. This will be discussed in more detail in Part VII of this paper.

Part II - Uncontrolled Photographs

(a) Problems of Scale

An aircraft engaged in aerial survey, flies at a constant altitude - that is, a constant height above mean sea level. However, the scale of the photograph depends on the height above ground level. Consequently, the scale will only be constant if the ground is completely flat - an extremely rare occurrence!

In reality, as the ground rises and falls beneath the aircraft, the image will grow larger and smaller on the film, leading to a continually changing scale.



It is apparent in the above diagram, that this photograph would not have a constant scale. The area at the top of the hill, being closer to the camera, would have a relatively large scale, falling off to a relatively small scale in the valley. Obviously, no accurate measurements could be taken from this photograph.

This is the aerial photograph in its initial stage. Sometimes this is all that is required; planning boards usually employ this type of photograph because it is comparatively inexpensive but still shows all that the planner needs.

The assessment draftsman may be able to obtain uncontrolled aerial photographs from a wide variety of sources. Any agency that has conducted an aerial survey - the Department of Highways, the Department of Lands and Forests, Planning Boards, Municipal Engineering Departments, Conservation Authorities, etc. - will have this type of photo as either the first stage or the final product, depending on individual needs.

This type of photograph is useful to the draftsman in showing the features to be drawn, indicating creeks, fences, etc.; it is also very valuable to the assessor visiting the property - in the rural areas at least. However, it would be dangerous to place too much reliance on scaled distances!

(Another factor to be considered is that lens distortion is inevitable, and so even if the ground is perfectly flat, only the centre of the picture will be true to scale. No measurements should be taken at the edges, but the overlap is sufficient to render this unnecessary).

In spite of its weaknesses, however, in some rural areas, the uncontrolled photograph may be the best source of information available to the draftsman. In many cases, it will be more accurate than the original township survey, and if there is some way of checking the scale, by measuring distances on the photograph, and the terrain is fairly flat, it may be quite acceptable.

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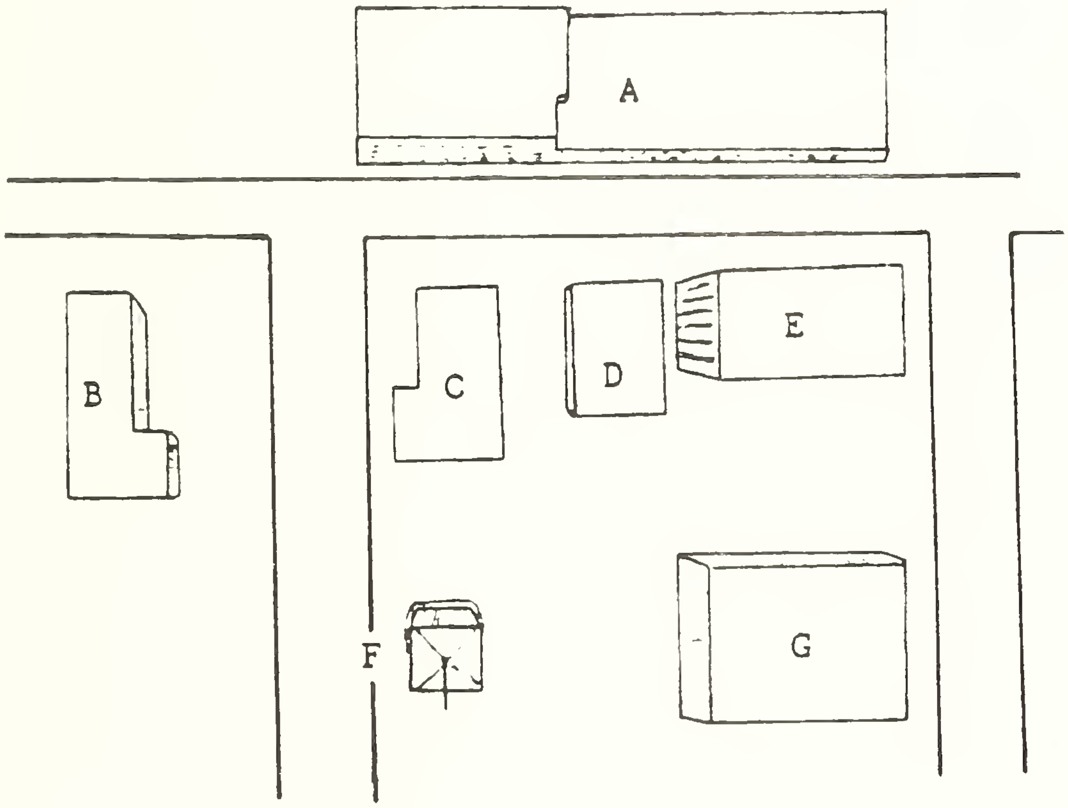
(b) Relief Displacement

There is one other consideration when using aerial photographs, and that is 'relief displacement'. The camera lens is at one point in space, and therefore, it is only vertically above the 'ground plumb point'. Every point not directly under the camera will be viewed from a slight angle. With unimproved land, this is not apparent, but a photograph of tall buildings reveals that every buidling except the one right under the camera (normally the centre of the photo) appears to be leaning outward as the camera records a slightly oblique image. This, of course, is how the scene would appear to the unaided eye if viewed from above.

The following sketch illustrates this effect:



It is apparent that building 'C' is at, or very near, the plumb point, since all the other buildings display a slightly oblique view. It is also apparent that if we measured the distance between the roofs of buildings 'B' and 'E', or the roof of building 'A' and the top of the radio mast on building 'F', we would not obtain their true horizontal distances. We would get quite a different result from that obtained by measuring between the bases of these buildings. The roofs of the buildings are not in their correct positions relative to each other; this is called 'Image Displacement'.

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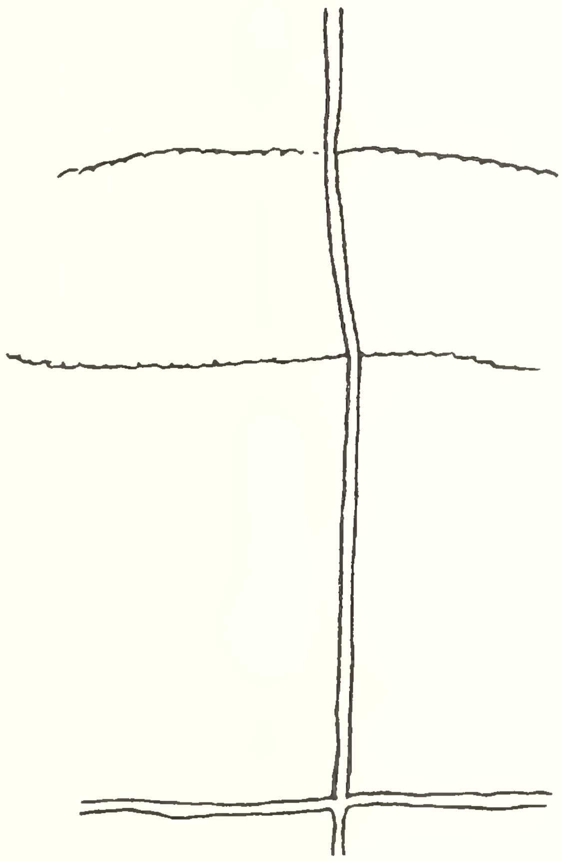
Now, suppose that instead of buildings, the photograph was of mountains. The peaks would be displaced in exactly the same way. This time, however, the displacement would not be apparent! There would be no way of measuring the true distance between peaks. This is called 'Relief Displacement', and it exists to some extent whenever the ground is not flat.

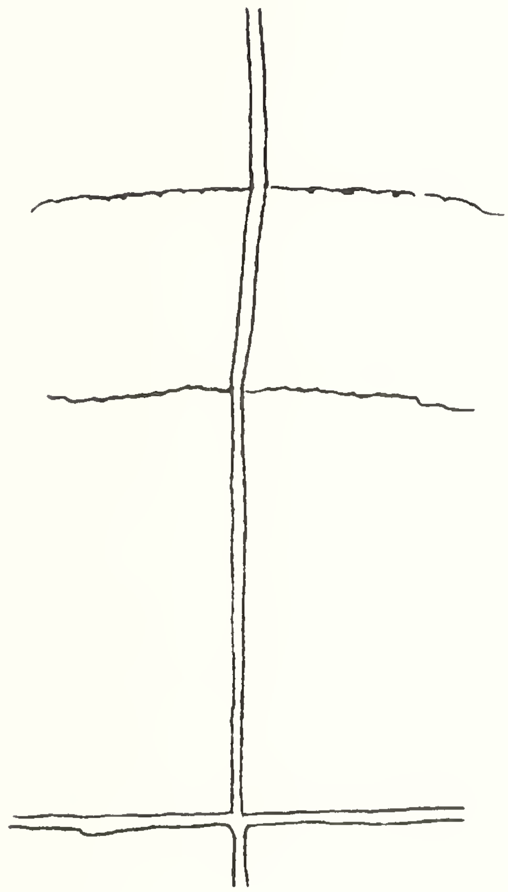
A draftsman using uncontrolled photographs of rugged terrain should bear this effect in mind if scaling distances. No photograph will be accurate far from the ground plum point, or where severe changes in elevation occur.

One effect of relief displacement is illustrated in the sketch below:



This represents a gravel road entering a strip of bush. It makes a slight turn to the left and proceeds at an angle until it reaches open ground again, then makes a slight turn to the right and continues on a course parallel to the original road. A draftsman working from this photograph would feel justified in moving the northerly part of the road about one road width to the west.

However, the adjacent photograph is as follows:



Here, the road angles towards the right on entering the bush, and then straightens up to run parallel to the original road but about one road width to the east!

The explanation lies in relief displacement. The strip of bush is on the face of a steep slope with relatively flat land above and below. The angle of the camera to the change of grade causes an apparent shift in the road location. When the two photographs are viewed stereoscopically, the road is straight!

(c) Photographic Mosaics

Individual photographs are sometimes pieced together to form sheets covering fairly large areas. These are called mosaics - the best example is probably the series prepared by the Silviculture Section of the Department of Lands and Forests, examples of which should be available in every assessment office.

Photographic mosaics are invaluable in a mapping programme. They provide the draftsman with a general picture of the area under consideration, showing the locations of railways, rivers, highways, lakes, swamps, and so on.

However, they suffer from the combined effects of relief displacement and lens distortion. Although they are rectified to some extent, the photographs forming the mosaics are adjusted to fit each other rather than to fit the facts! A completed mosaic will rarely match an adjacent one.

Consequently, although they provide an excellent picture of the area, they are only approximately to scale. One could determine, for example, that a railway intersected a lot line 7/10 of the distance from one lot corner to the other, but one could not determine, from the mosaic, just how many feet this would be.

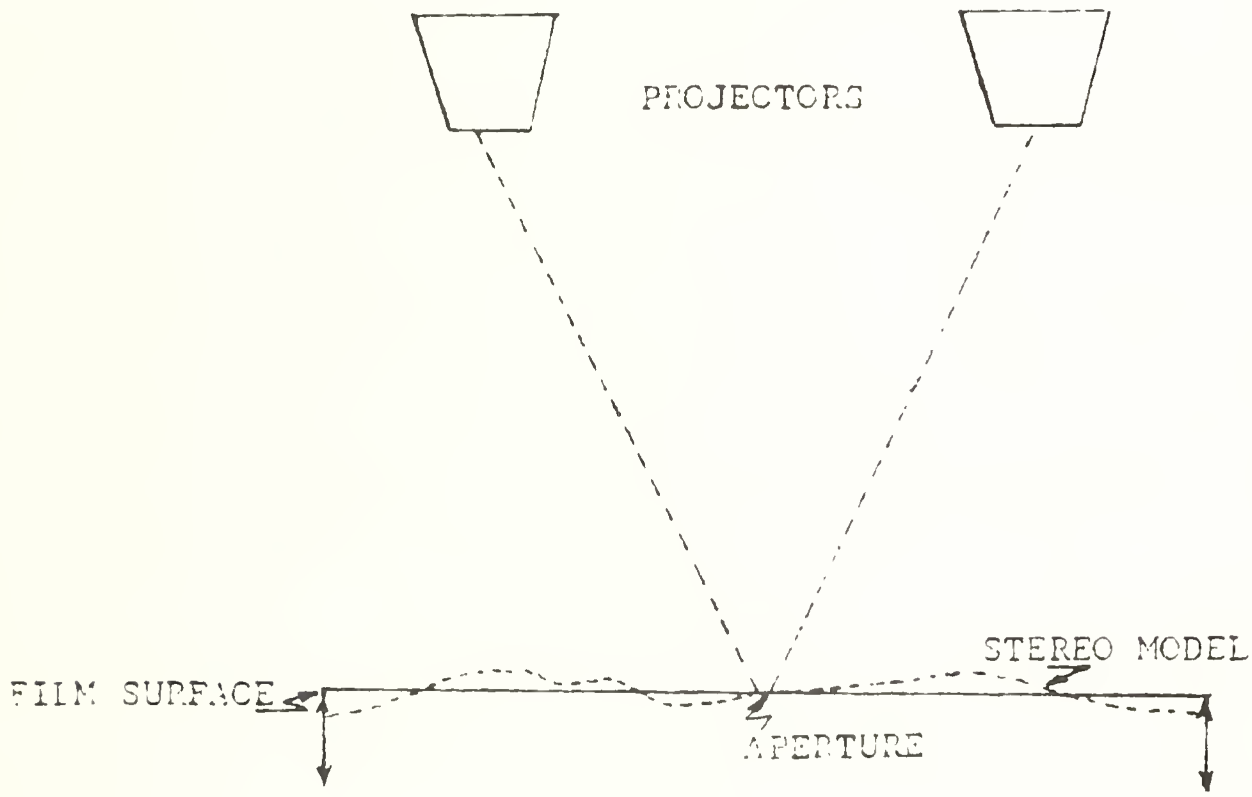
All the weaknesses of uncontrolled photographs discussed earlier are magnified on the mosaic owing to its size, but it is still relatively accurate, and it would be difficult to imagine a mapping programme commencing without a set of photographic mosaics. $5.00 sheet covers thousands of acres, and provides an over-view of the mapping project that cannot be obtained by any other means.

They can be obtained from:

Air Photo Library,
Whitney Block, 3rd Floor,
Queen's Park,
Ministry of Natural Resources,
TORONTO, Ontario. 965-6914

Part III - Orthophotos

An orthophoto is a reproduction of a mosaic in which distortions caused by relief are removed, making the picture true to scale. This is a fairly sophisticated process, but can be simply illustrated by the following diagram:



Two projectors create a stereo model and film is exposed in a narrow moving band, through a small slit or aperture. As the aperture moves slowly across the surface, the film is raised or lowered so that it is always at the elevation of the stereo model. (This is similar in principle to the floating mark, referred to in the discussion of the stereoplotter.)

The film is scanned in a series of strips until the entire stereo model has been recorded on film. The raising and lowering of the film during exposure compensates for the relief variations in the original film. It cancels out scale changes, while eliminating relief displacement because of the stereo viewing.

Difficulties may occur with sudden changes in elevation, such as cliffs or tall buildings. The film must be scanned at a constant rate to avoid over or under exposing the film. In the case of a vertical cliff, the machine is unable to adjust quickly enough, so the cliff may appear on the orthophoto as a steep slope. Also, in a few instances, there may be 'hidden ground' behind tall buildings that cannot be seen by the cameras.

However, the orthophoto is superior in all respects to the ordinary photographic mosaic, and can be used to measure distances and acreages quite accurately.

Part IV - Interpretation of Aerial Photos

Before plans can be drawn, or any use made of the photo, it must be studied and the different features identified.

Not only the colour, but the texture of a surface determines whether it shows dark or light on the print. The smoother the surface the lighter in tone it appears, so that a black asphalt road shows white! The one exception is the surface of deep water which, if unruffled, acts like a mirror and in almost all cases reflects all light away from the camera. Only occasionally does the angle of reflection strike the camera lens. At all other times, deep water appears black. Shallow water appears grey because there is a diffusion of light rays reflected from the uneven bottom of the pond, lake or river.

The most practical training in interpretation comes from taking the picture into the field and comparing the various objects as they appear on the ground and on the photo. There, one can observe the variation in picture tone caused by difference in texture.

A ploughed field is slightly darker, in the picture, than the adjacent field which has been harrowed. One could, in fact, build up a tone-texture scale ranging from a smooth road or roof, appearing white, through rolled soil, harrowed soil, short grass, root crops, hay or grain, underbrush, hardwood forest, and coniferous forest, which last is the darkest on the scale. The determining tone factor is the proportion of contained shadow to the reflecting surface.

One interesting exception to the tone-texture rule is damp soil, which appears darker than dry soils of the same texture.

Fences usually show plainly on vertical photos. At normal photo scales of around 100 feet to the inch, the wire and posts of a fence are too small to be visible, but if the fence has been in place long enough, the grass and weeds alongside will have reached sufficient height to mark a darker line on the print. Only a wire fence less than a year old is likely to be missed. The characteristic pattern of a snake rail fence is unmistakeable. By way of warning, a narrow drainage ditch, with long grass along its edges, looks almost exactly like an old wire fence in the photo.

However, even in unfamiliar territory accurate interpretation can be carried out by close observation and careful reasoning. A railway, for instance, can be distinguished from a highway by several small signs - the absence of turn-outs onto intersecting roads, steeper embankments and deeper ditches, and generally flatter grades. Often the association of several objects gives the best clue to their identity - a large building behind several smaller ones at the end of a driveway crossing open fields is obviously the barn of a farm, or a row of identical small buildings close to a highway is most likely a motel. Haystacks or lumber piles may resemble buildings, but their relation to roads or paths, fences, etc., should point out the difference. In addition, the shadows of structures often reveal their shape and thus, their identity.

Part V - Maps Prepared from Photographs

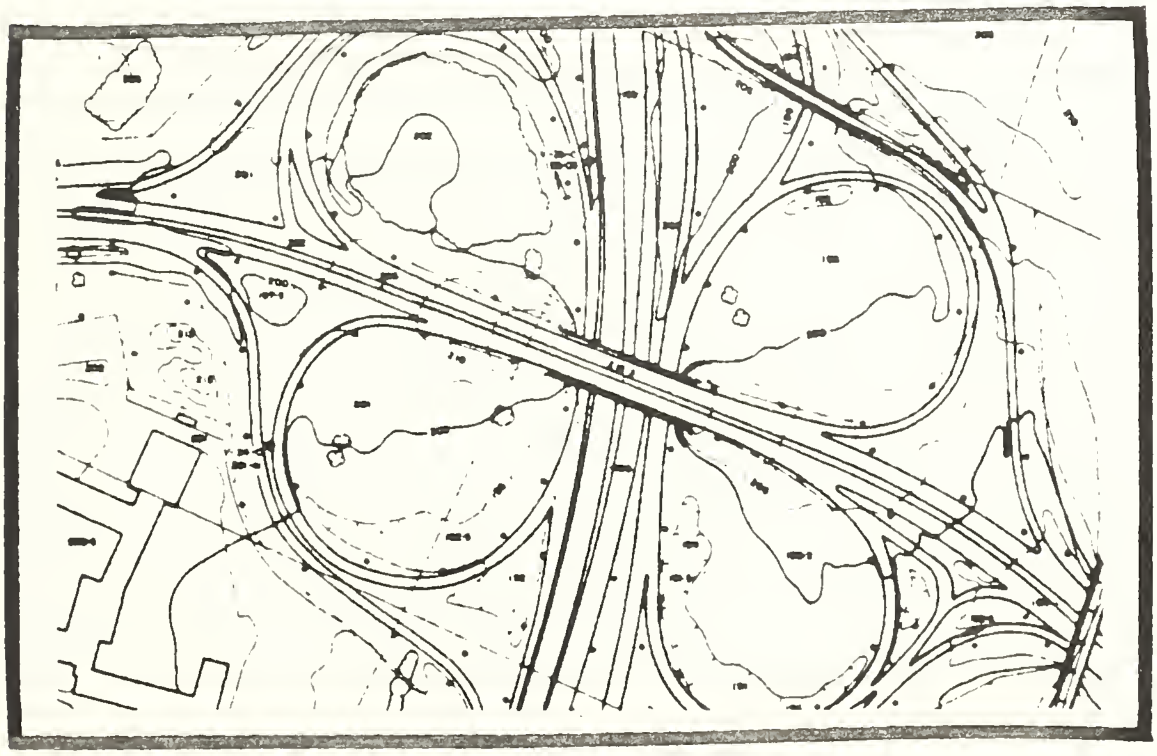
Aero Triangulation

Aerial mapping requires a ground survey to establish precise distances and elevations. A survey party will set monuments and benchmarks at strategic locations - the number depending on the accuracy required. These points are marked with conspicuous 'targets' so that they will be clearly visible on aerial photographs.

The photographs are taken and the control points identified. These form a series of triangles linking the photographs together. Since the precise distances between monuments, and the exact elevation of benchmarks, is known, the photographs can be adjusted with the aid of a computer and sophisticated plotting equipment. All the ground control points are brought into the correct relationship with each other to produce an undistorted record of the area under study. A map can then be drawn with the stereoplotter.

Planimetric Maps

The stereoplotter produces the familiar line map illustrated below:



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These are accurate! The draftsman who is fortunate enough to have a set of large-scale planimetric maps at his disposal has few problems with lot sizes, overlaps, missing bearings, etc. The fences are clearly indicated, and the draftsman can sit with the deeds before him and follow the lines of occupation with ease.

Aliquot parts can be drawn exactly as occupied, and irregular boundaries plotted accurately. Acreages can be determined with a planimeter, depth of gravel pits determined straight from the map, and so on. The large-scale maps are so accurate that highways and railroads are designed from them before a survey crew ever sets foot on the property.

These maps are frequently prepared at scales of 1" = 200', or larger, and may be available from conservation authorities, large developers and railways, in addition to the Department of Highways.

Needless to say, the aerial survey companies themselves are an obvious source of these maps, but their prices are often too high. Nonetheless, it is often worthwhile contacting them and if the photographs are readily available, the companies may be willing to negotiate. A list of such companies is included in Appendix B.

An example of the development of planimetric maps from aerial photographs is shown in the following pages.*

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*These examples were compiled and drawn by Western Photogrammetry Ltd. for The Municipality of Metropolitan Toronto.

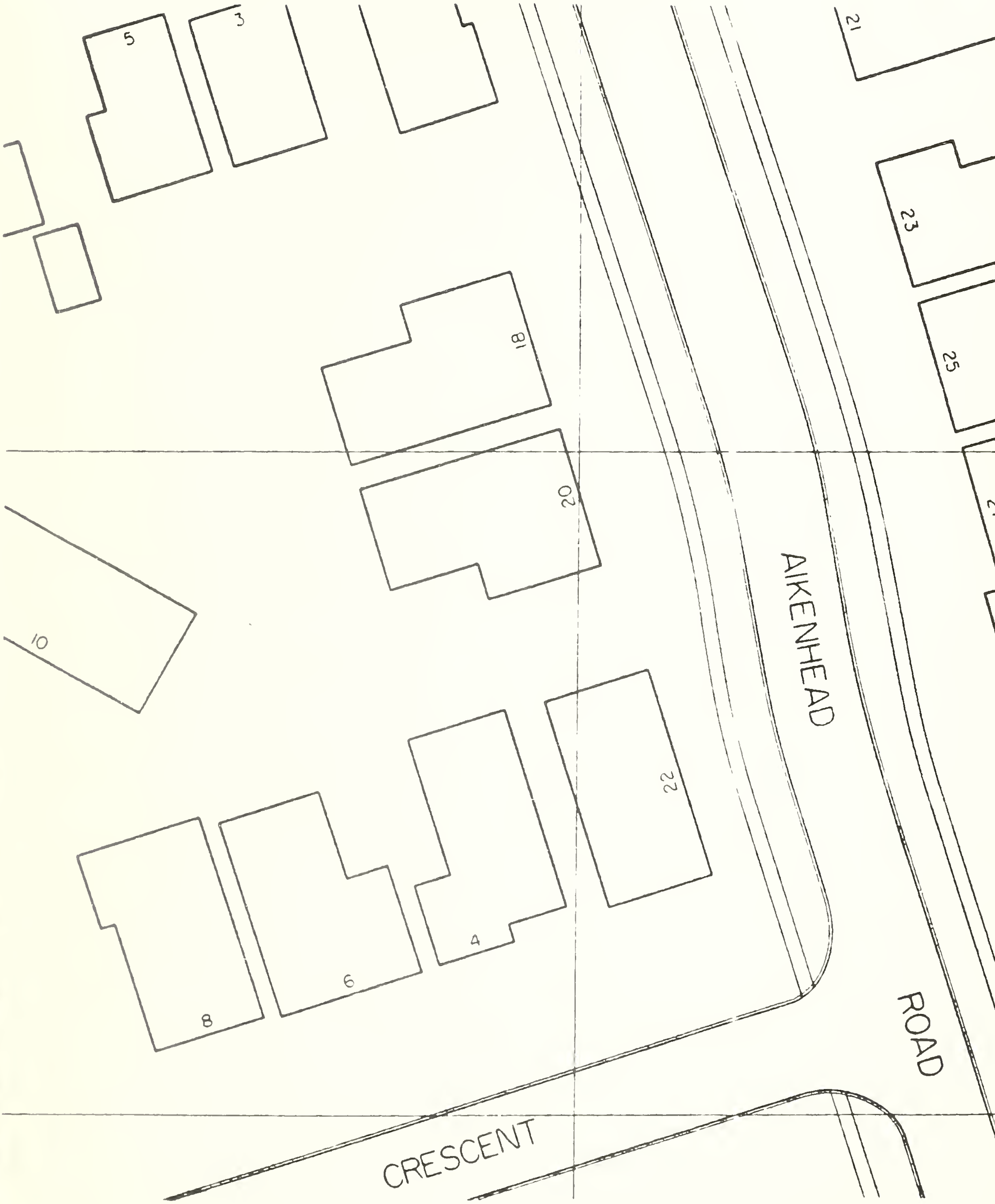
1. The first illustration shows an aerial photograph, at a scale of 1" = 40', of part of a residential area.

2. Next comes a line drawing of the physical features, drawn with a stereoplotter. Street names and numbers have been added. This type of map is often prepared for planners. It should be remembered, however, that the 'building shapes' are actually the roof shapes, and the actual building diagram prepared by the assessor may be slightly different.

3. In the next illustration, contour lines and spot elevations have been added. This information is often required by planners and engineers, and is useful to assessors. However, the assessment draftsman will only be interested in this feature if there are sharp variations in elevation that should be noted on the assessment maps, eg. ravines.

4. This shows the same area with the addition of lot lines, lot numbers and plan numbers. It is now in its most useful form as far as the assessment draftsman is concerned.

5. Finally, we see the underground services. This type of information is needed by the assessor, but may be of little concern to the draftsman. Therefore, when the draftsman obtains maps of this type, he should pass them on to the assessors as soon as possible.



LINE DRAWING OF PHYSICAL FEATURES

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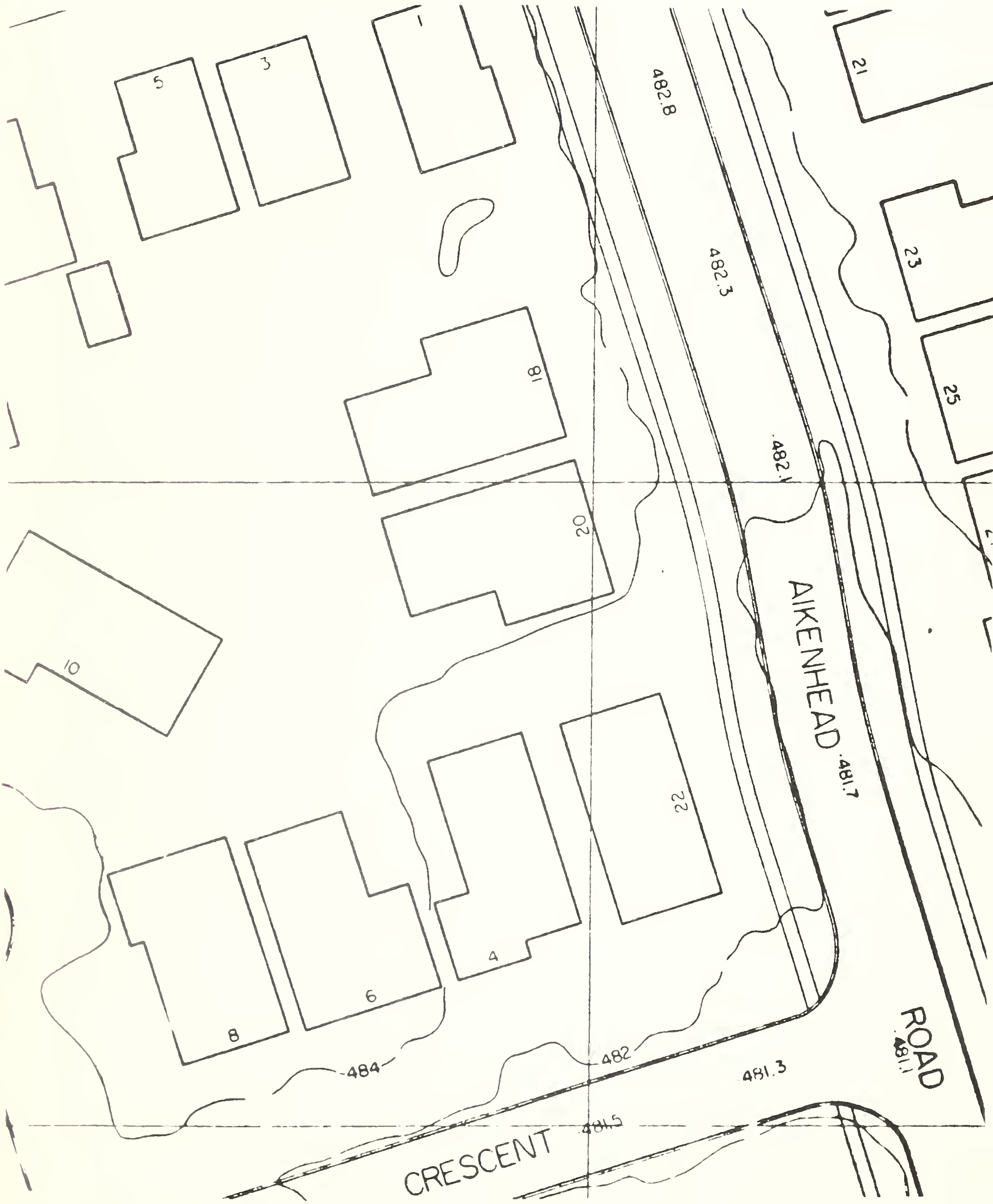

CONTOURS AND ELEVATIONS ADDED

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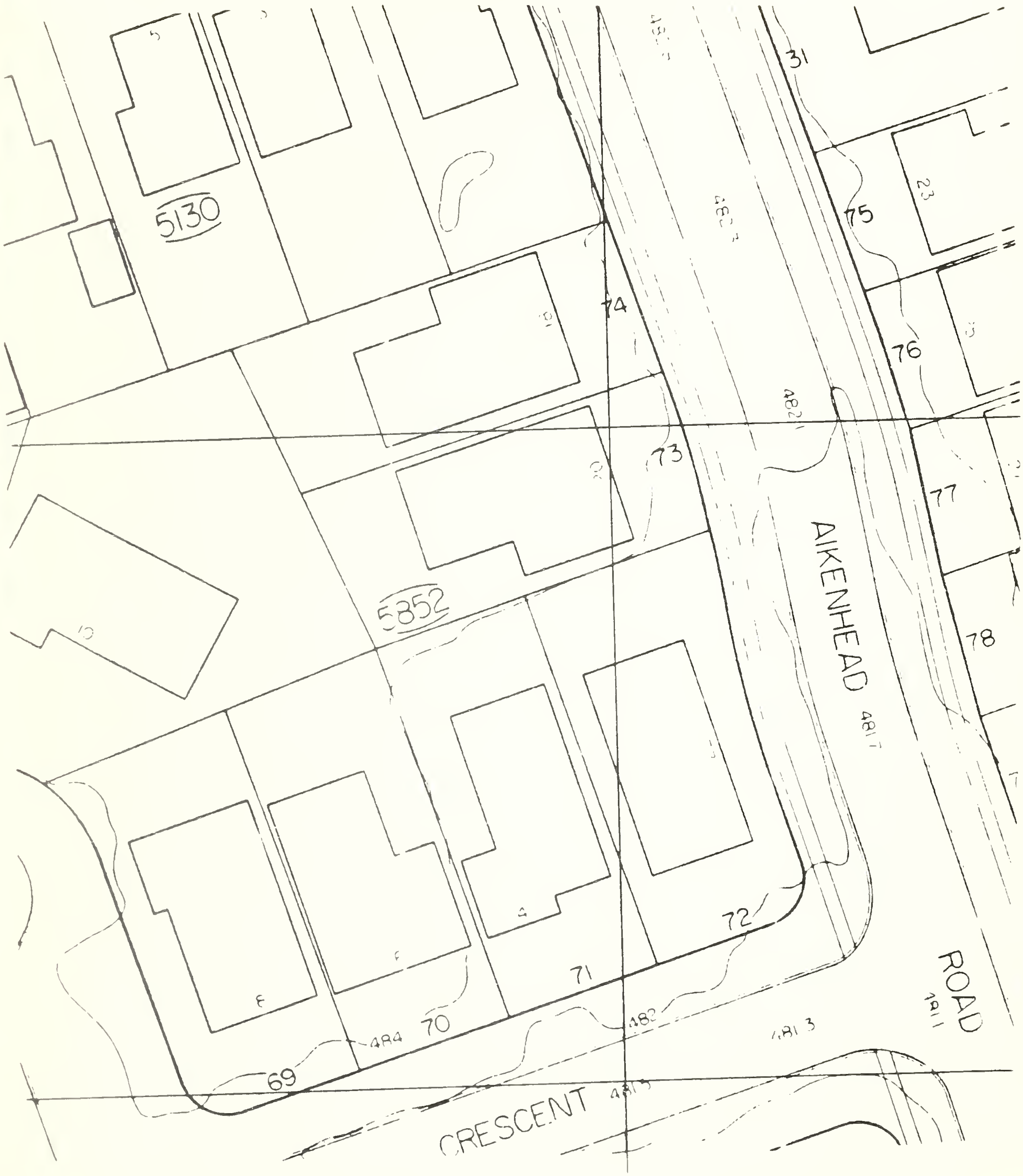
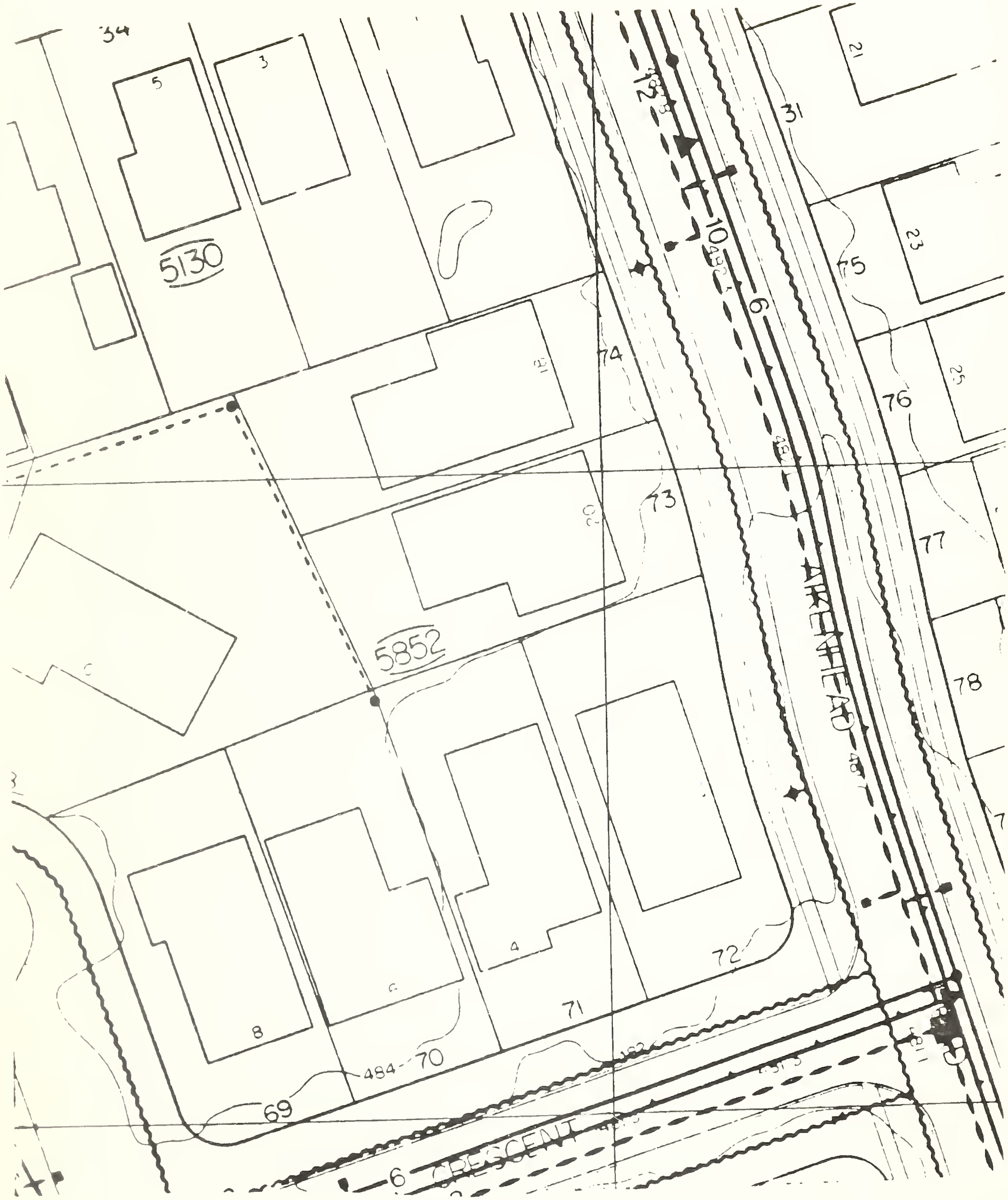


REGISTERED LOTS ADDED



UNDERGROUND SERVICES ADDED

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Part VI - Other Aids to Mapping

There are some additional maps which can be used in conjunction with aerial photographs to provide a fairly complete picture of the land pattern. Land Use and Land Capability maps can be a valuable supplement to photographs, particularly for the assessor.

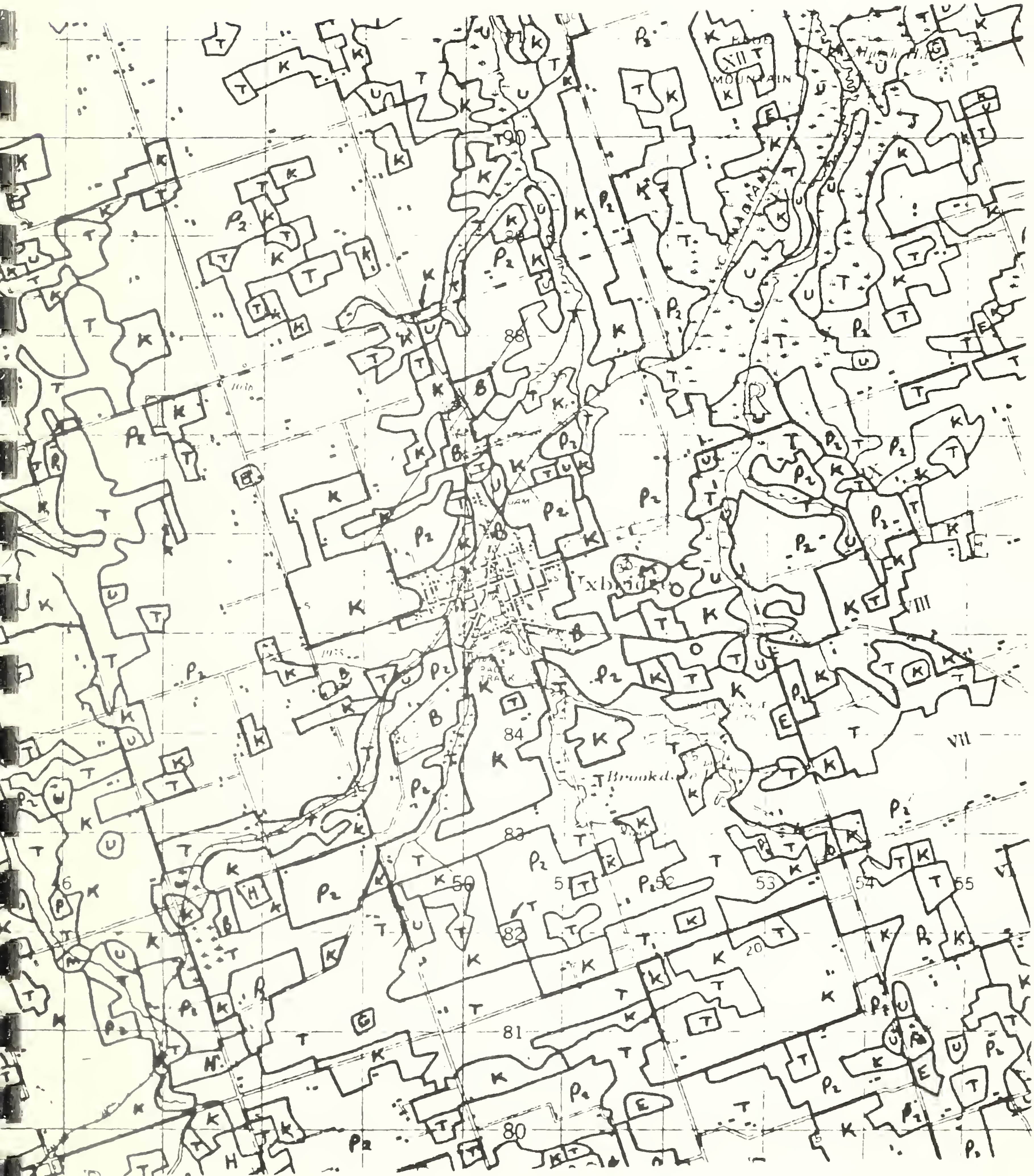
(a) Land Use Maps

The following sample indicates the general characteristics of these maps:

Land Use Mapping Project A.R.D.A.

I N D E X

MAP SYMBOL	CATEGORY NAMES
B	Urban Built-up Area
E	Urban Mines, Quarries, Sand & Gravel Pits
O	Urban Outdoor Recreation
H	Horticulture
G	Orchards & Vineyards
A	Cropland
P	Improved Pasture and Forage Crops
K	Improved Pasture and Range Land
T	Productive Woodland
U	Non-Productive Woodland
M	Swamp, Marsh or Bog
S	Unproductive Land
L	Unproductive Land
Z	Water



These maps are of considerable value to the rural assessors, and the draftsman can be of assistance in relating this data to individual farms and smallholdings. It is possible that this information could be incorporated onto some of the maps prepared by the mapping office; for example, a map drawn at 1" = 1000' showing farm boundaries could have this type of data included.

(b) Land Capability Maps

These are similar in general concept, but the characteristics shown are related to the capability or potential of the land for farm use. Type and depth of soil, degree of stoniness, drainage, topography and climate are considered. Soil information was obtained from the old County Soil Survey Maps, which means that these maps can only be as detailed as the original surveys.

The land capability classification was developed in the U.S.A. and adjusted for Canadian conditions by ARDA. The purpose of the classification is to come up with a common set of characteristics for all of Canada, by which <u>all</u> soils can be judged in terms of their capability for agricultural purposes. This was needed because soil surveys in Canada have varied from province to province and even from county to county!

These maps are useful to the assessor as a first step in a more scientific and objective method of evaluating soil conditions. The assessor must, however, consider other factors such as technology, land use, nearness to markets, climate, etc., which all affect land value.

Once again, the draftsman may be of great assistance in relating the soil capability to individual farms, or possibly preparing special purpose maps. An example of the ARDA series is included in Appendix "C".

Part VII - Geocoding

(1) Introduction

In Part I, we touched briefly on the subject of computerization and the Grid Coordinate System. This is a very important topic as far as assessment mapping is concerned, since the mapping staff can expect to be participating directly when this system is introduced. Certainly, no one would be better qualified to implement this system than the mapping draftsman.

The assessor is concerned with location when determining the value of property. As yet, however, the advent of computer use in assessment has not been paralleled by the adoption of a filing system that defines the specific and unique location of properties. Thus the relative locations of properties (i.e. distance from a given property to schools, subways, etc.) has not been included in valuation in a consistent way. It is with this in mind that the adoption of geocoding (sometimes referred to as GRDSR - Geographically Referenced Data Storage and Retrieval System) would assist the assessor in determining the effect of location on value.

(2) The Technique

Geocoding is a refined technique of geographically coding locations by assigning to each of them co-ordinate values based on longitude and latitude. On this basis, once information relating to a property is known, it can be filed by attaching to it the appropriate geographical co-ordinate. The co-ordinate for a given property is defined by the centroid. For rural properties the centroid is a point situated at the centre of gravity of the property unit.

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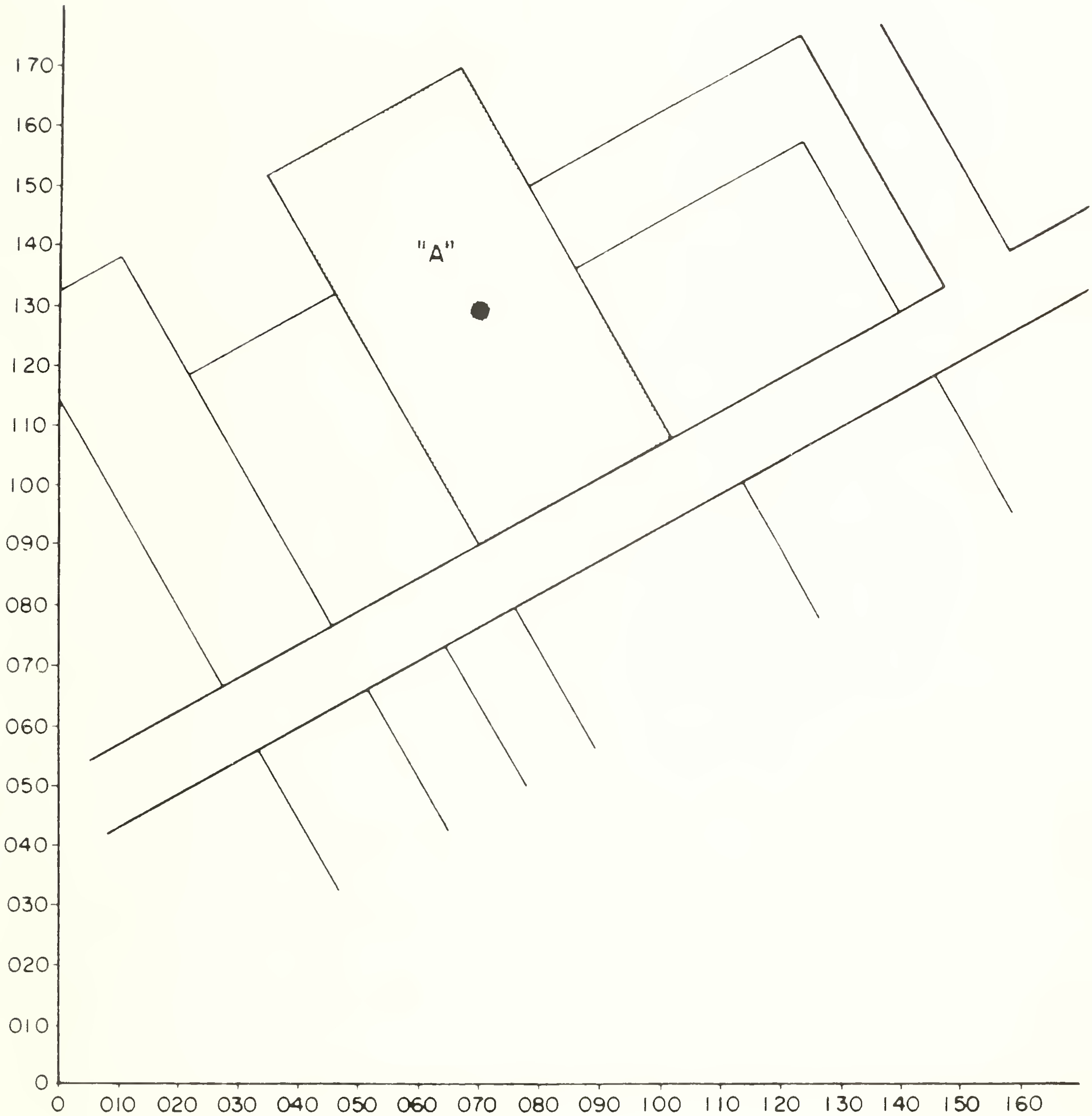
GEOCODING — EXAMPLE OF PRINCIPLE



GEOCODE OF LOT "A" = COORDINATE OF CENTROID
= 070 130

For urban areas a degree of generalization is accepted and the centroid is generally the mid-point of the block-face recessed a standard distance from the street centre line. There are several ways of generating the geocode for centroids of urban properties:

(a) Deriving the Centroid

(i) Political Units, Streets, etc.

This method of deriving a geocode is somewhat similar to the approach used in developing assessment roll numbers. It has the advantage that assembly of data by streets or segments of streets is extremely simple. It has the drawback that computerized printout of data in map form is virtually impossible since the actual location of the property on the street cannot be identified.

eg.

County	Municipality	Ward	Street	Street segment	Street Number
011	031	067	016	004	06315

(ii) Geographical Coordinates

The ultimate geographical coordinate geocode would be expressed in terms of latitude and longitude. In practice it is normally more convenient to adopt a coordinate system based on the map projection in use in the province.
In the case of Ontario, the following systems are in use:

- -Federal -The Universal Transverse Mercator (6° zones)
- -Provincial -The Ontario Coordinate System* which is derived from a U.T.M. projection modified for 3° zones. See Figure 2.

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* The Ontario Co-Ordinate System was defined by O. Reg. 301/69, made under the Surveys Act. See Appendix A.

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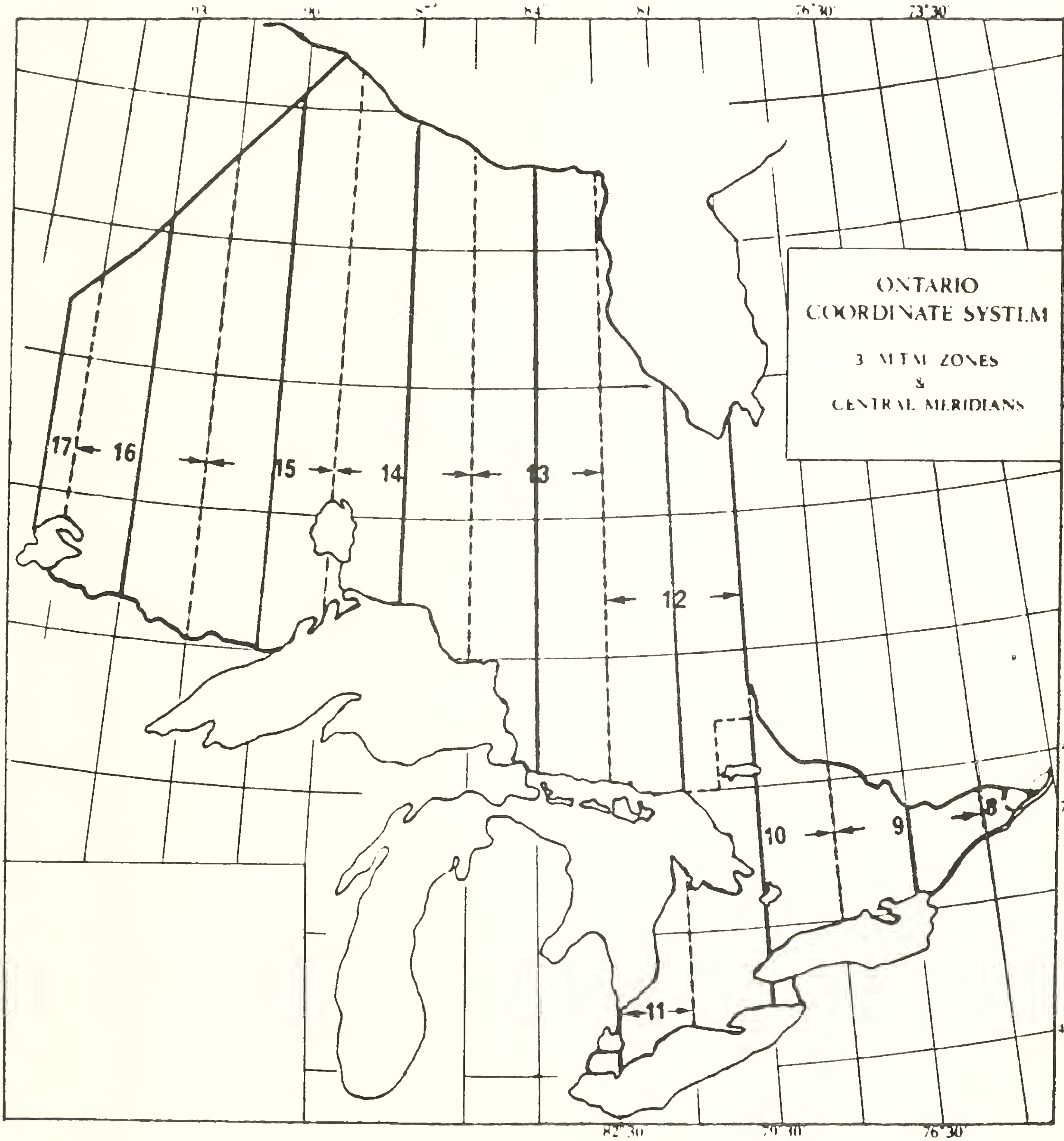
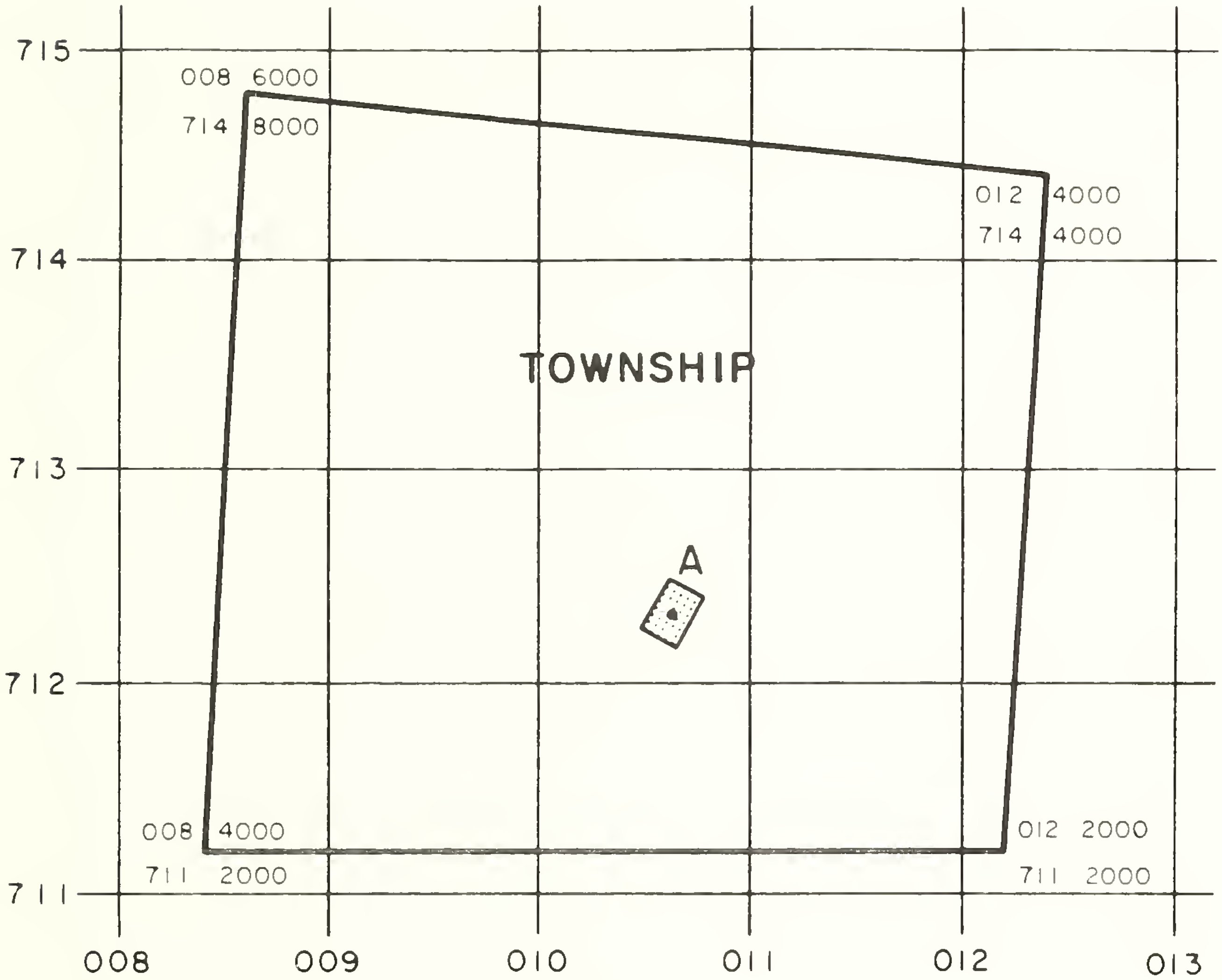

ONTARIO
COORDINATE SYSTEM
3° MTM ZONES
&
CENTRAL MERIDIANS
17
16
15
14
13
12
11
10
9
8
76°30'
73°30'
84°
81
54°
50°
46°
73°
42°
82°30'
76°30'

Figure 2

Using coordinates as a geocode is better suited to strategic or regional planning than to more detailed work. Its main advantage lies in the relative ease with which data already recorded in map form can be coded. Limitations relate both to the difficulty of coding information not already in map form, and to the relative lack of precision.

DIAGRAM OF COORDINATE GENERATION



10,000 FOOT GRID SQUARES ON THE ONTARIO COORDINATE SYSTEM.

	COUNTY	TOWNSHIP	EASTINGS	NORTHINGS
GEOCODE OF LOT "A"...........	011	031	(01) 06278	(71) 23482

A geocode (based on co-ordinates) which described a defined area, potentially has many more advantages from the viewpoint of both recording and retrieving data.

e.g.

Eastings	Northings
6346273	.9573482

(iii) <u>Political Units, Plus Geographical Coordinates</u>

It may well be convenient, either to facilitate retrieval, or because the basic mapping from which the geocodes are to be granted is inadequate, to use a combined system. Such could well prove to be the best case for Ontario, where parcel boundaries and even township corners have not, as yet, been co-ordinated on the Provincial system. As individual parcel boundaries in Ontario do not normally cross township boundaries, there is some advantage to defining the township first as a political unit. Within the township individual parcels may then be identified by a point co-ordinated on as close an approximation to the Ontario Coordinate System as possible, this approximation to be derived by estimating the co-ordinates of township corners from existing mapping, and developing an internal grid from these points.

e.g.

County	Municipality or Township	Eastings	Northings
011	031	(01)06278	(71)23482

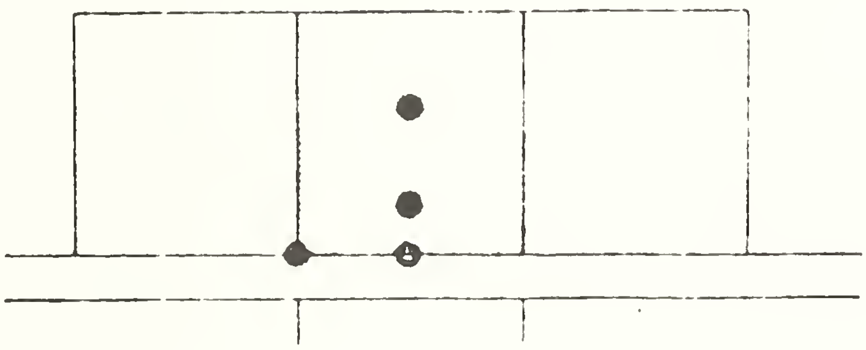
The figures in brackets are part of the co-ordinate reference, but are made redundant by the use of the county and township code.

(b) Defining the Area

Various ways of defining areas to be geocoded are possible, the more important of which will be discussed here. Of these, it should be noted that only one type, that which describes the parcel or individual land holding, is area specific; that is, it specifies an area which may be found both on the ground and and on the maps.

(i) In the case of geocoding by parcel, the centre point or centroid of the lot, a specific corner (e.g. the South-West), and the mid point of the road frontage have all been suggested for use.

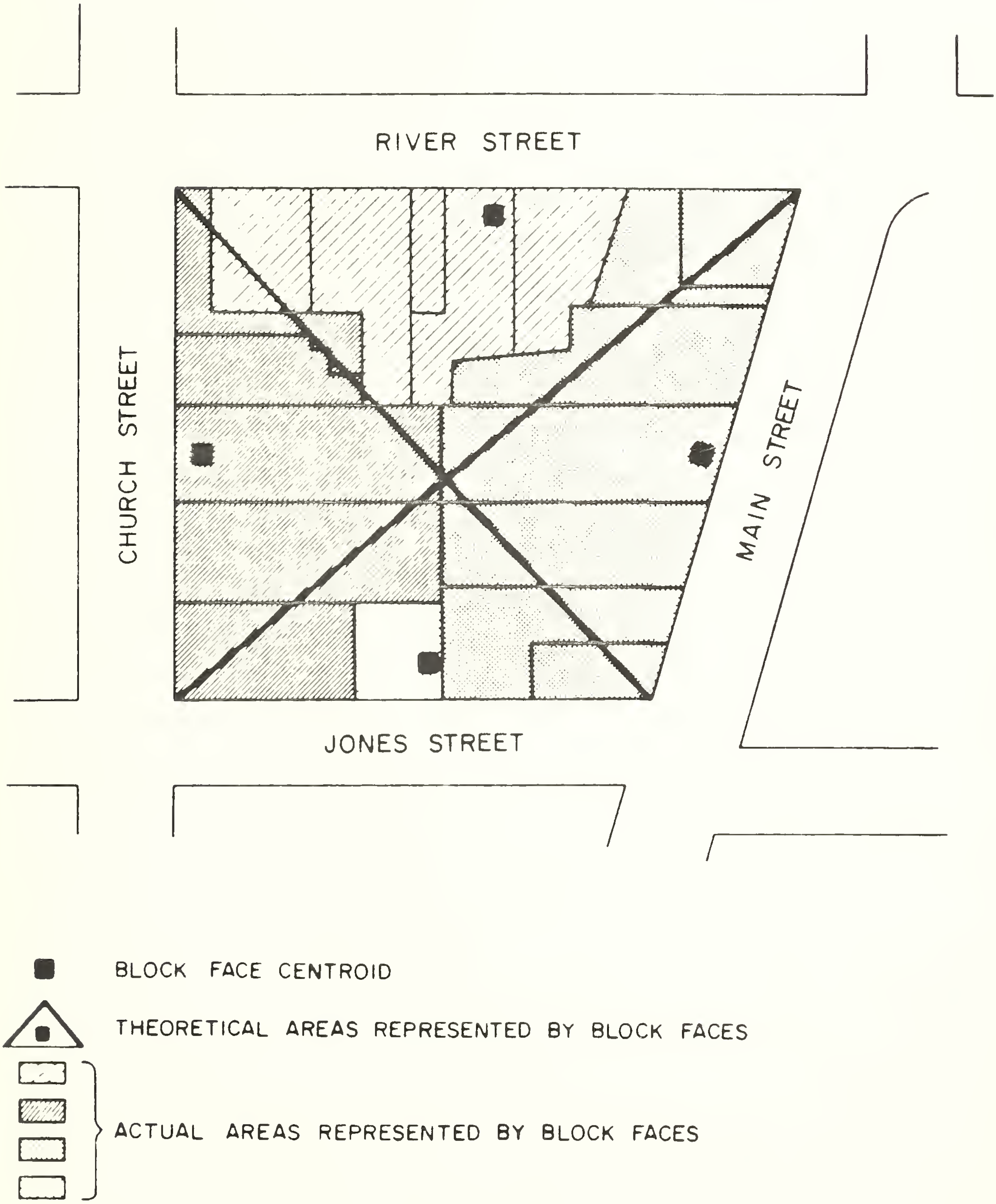
PARCEL



● ALTERNATIVE POINTS WHICH MAY BE COORDINATED TO GENERATE THE GEOCODE

(ii) The others relate to aggregations of parcels whose extent is not specified, but which have the common characteristics of frontage onto the street intercept, block face or street segment, or in the case of the grid square, to an area arbitrarily defined on the map, which has no visible existence on the ground. The block face system is not area specific. Thus on Figure 4, a typical block with four faces and four block face centroids is illustrated. The triangular areas shown are those which, in the absence of any information as to parcel boundaries, each centroid might be assumed to represent. The shading shows the actual area represented by each centroid, as derived from a map of property boundaries and a listing of street addresses.

A BLOCK FACE IS NOT AREA SPECIFIC

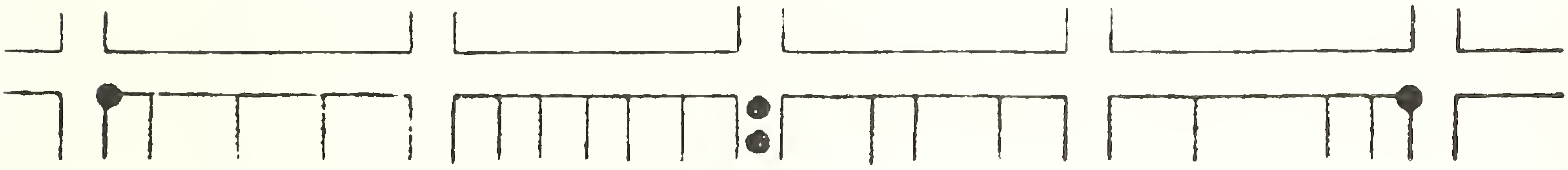


. . . 35

For the Street Length Intercept and Block Face, the point may be in the centre of the block, or at the end. It may be on the road frontage, or set back a specified distance. For the Street Segment, a likely choice would be in the centre of the street equidistant from each end of the segment.

STREET LENGTH INTERCEPT

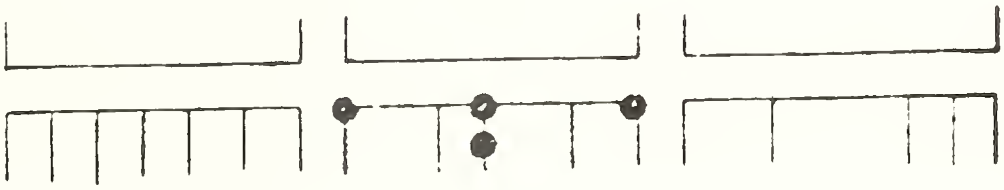
Includes all properties fronting onto one side of a section of a street. Typically an Intercept may be about four blocks long.



● ALTERNATIVE POINTS WHICH MAY BE COORDINATED TO GENERATE THE GEOCODE

BLOCK FACE

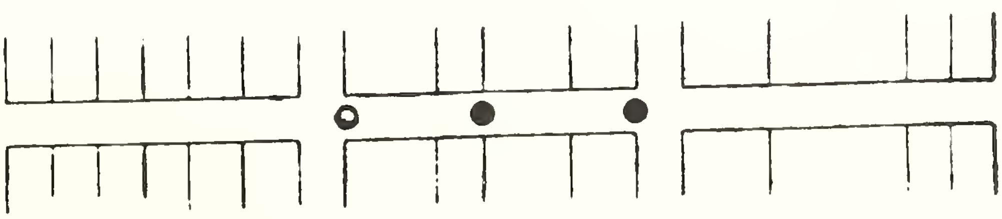
Includes all properties fronting onto one side of one street between intersections



● ALTERNATIVE POINTS WHICH MAY BE COORDINATED TO GENERATE THE GEOCO[illegible]

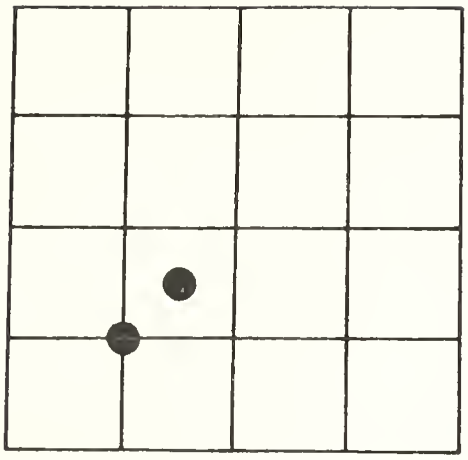
STREET SEGMENT

Includes all properties fronting onto both sides of one street between intersections.



● ALTERNATIVE POINTS WHICH MAY BE COORDINATED TO GENERATE THE GEOCODE

GRID SQUARE



Units of land arbitrarily defined bounded by grid lines on the map projectio

● ALTERNATIVE POINTS WHICH MAY BE COORDINATED TO GENERATE THE GEOCODE.

(3) Proposed Provincial System and Advantages

A considerable number of government ministries are actively considering implementation of geocoding. Among the ministries which have shown interest are the Ministry of Natural Resources, Transportation and Communications, Ministry of Consumer and Commercial Relations, The Ministry of Treasury, Economics and Intergovernmental Affairs, and The Ministry of Revenue. It is not the purpose of this paper to outline all the uses which other departments have, except to say that there are a great variety of uses envisaged. What all users do have in common is the need for a consistent data base and one which, if possible, will identify individual property units.

For The Province of Ontario, there would seem to be very great advantages in (1) making geocoding area specific, hence basing it on individual parcels of land, and (2) deriving the centroid using both political units and geographical coordinates. In this connection the CULDATA* System developed at the University of Cincinnati has been proposed. This system has the following potentials:

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* The acronym for Comprehensive, Unifield Land Data System is the CULDATA System.

"First. Description of land by use of coordinates which are tied in to the national control system and which meet recognized legal standards for land description."

"Second. A modern system of land title records with an index by parcels as well as by owners."

"Third. Use of a code number for each parcel indicative of its geographic location."

"Fourth. Use of same parcel code numbers for land titles, taxation, land use and land planning.

"Fifth. Use of a grid system of plane coordinates, or two or more compatible grid systems of plane coordinates of which at least one meets legal standards of accuracy for land surveys and the coordinates of each system are readily convertible into longitude and latitude and also into the coordinates of the other system. Also use of aerial photography, orthophotography, photogrammetry, modern devices for measuring distances, electronic data processing, microphotography, and modern devices and systems are available and if properly used may produce substantial savings as well as increased efficiency in the collection, storage, retrieval and use of land data."

"Sixth. Coordination of local, provincial and federal activities in the collection, storage, retrieval and use of land data, including use of standard code manuals."

The system is envisaged as having the following characteristics:

"a. It will provide unique identification and description for every parcel of land in the province."

"b. It will be useful from the date of adoption forward in time, without disrupting any past records."

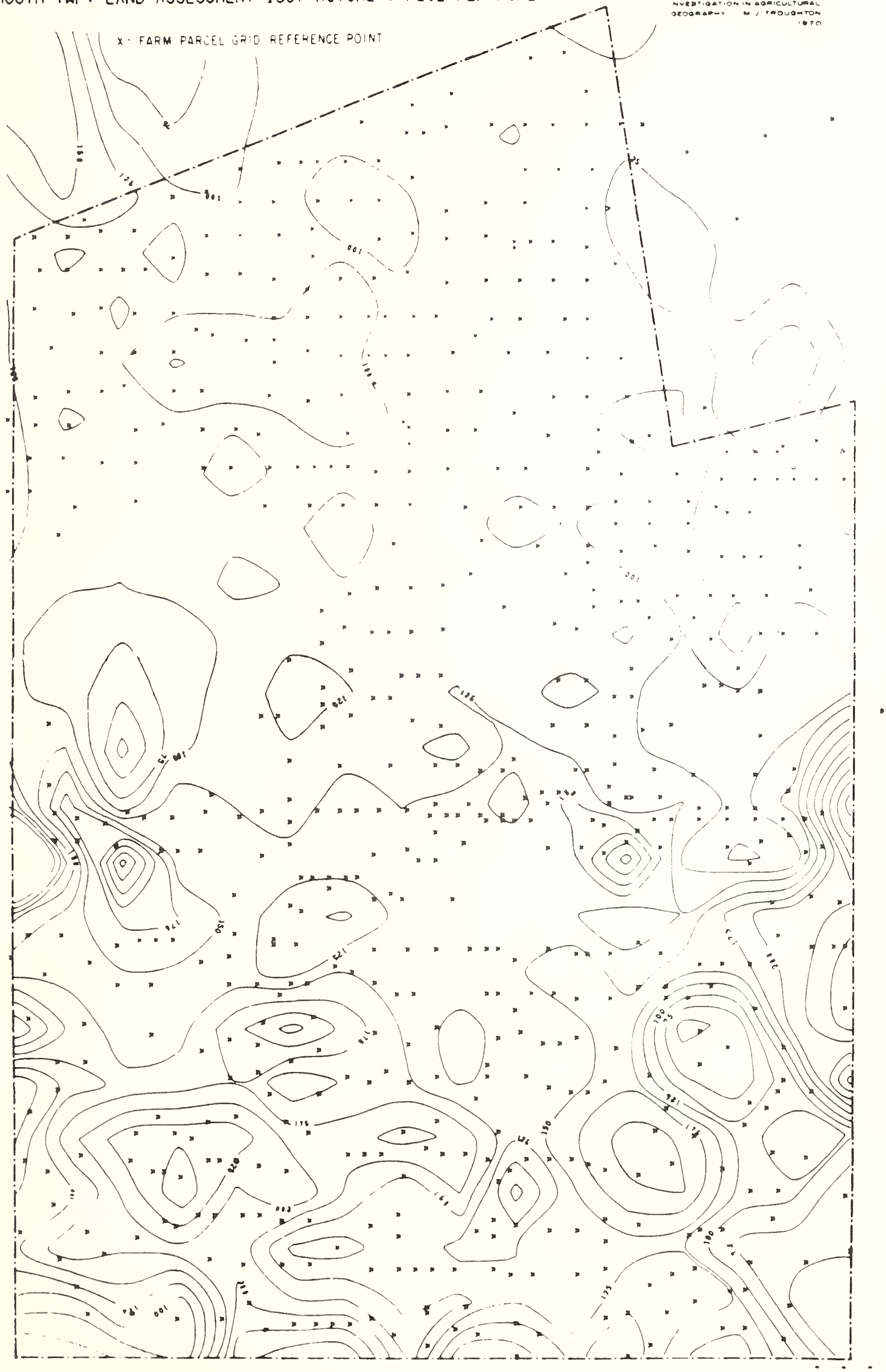
"c. It will be applicable to past records when, and if, a local unit of government desires to incorporate past records into the system.

(4) Some Actual Applications

The Erie Research Project based at the University of Western Ontario (and financed by a grant from The Department of Treasury and Economics) geocoded all assessment data for Oxford, Middlesex and Elgin counties for the year 1967. Some attempts at retrieval included computer maps of farm assessment per acre, as opposed to average per acre sales prices for farms, and retrieval of urban assessment information; in this case, data is based on block frontages and corners. The assessor would find such maps of great assistance in valuation. Examples of these maps follow, and at the end of this Part, a copy of the Regulation pertaining to the Ontario Coordinate System is included.

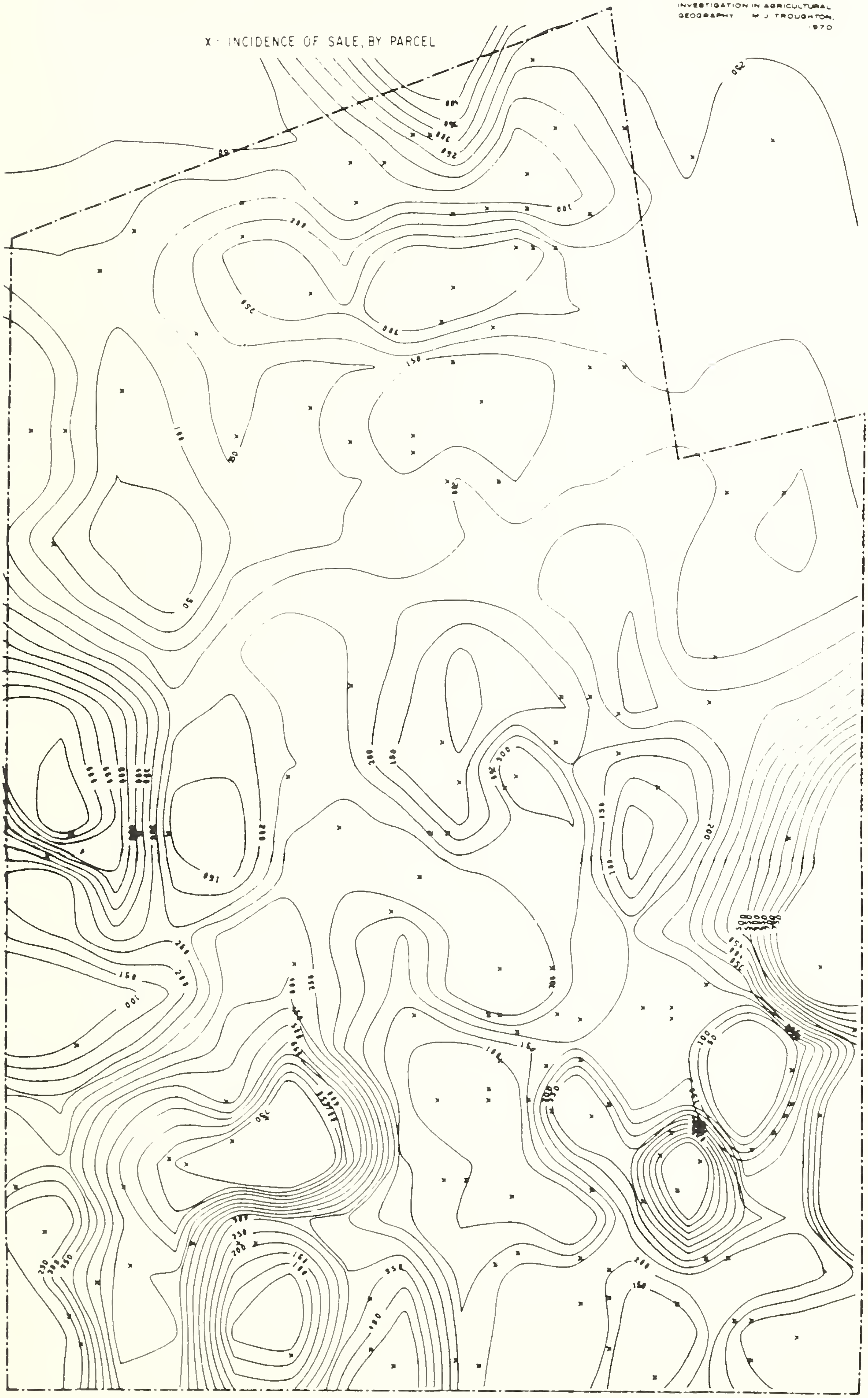
YARMOUTH TWP. LAND ASSESSMENT 1967 ACTUAL $VALUE PER ACRE

REPRINTED FROM FARM LEVEL INVESTIGATION IN AGRICULTURAL GEOGRAPHY M.J. TROUGHTON 1970



YARMOUTH TWP. FAF ALES 1957-68 $VALUE PER ACRE

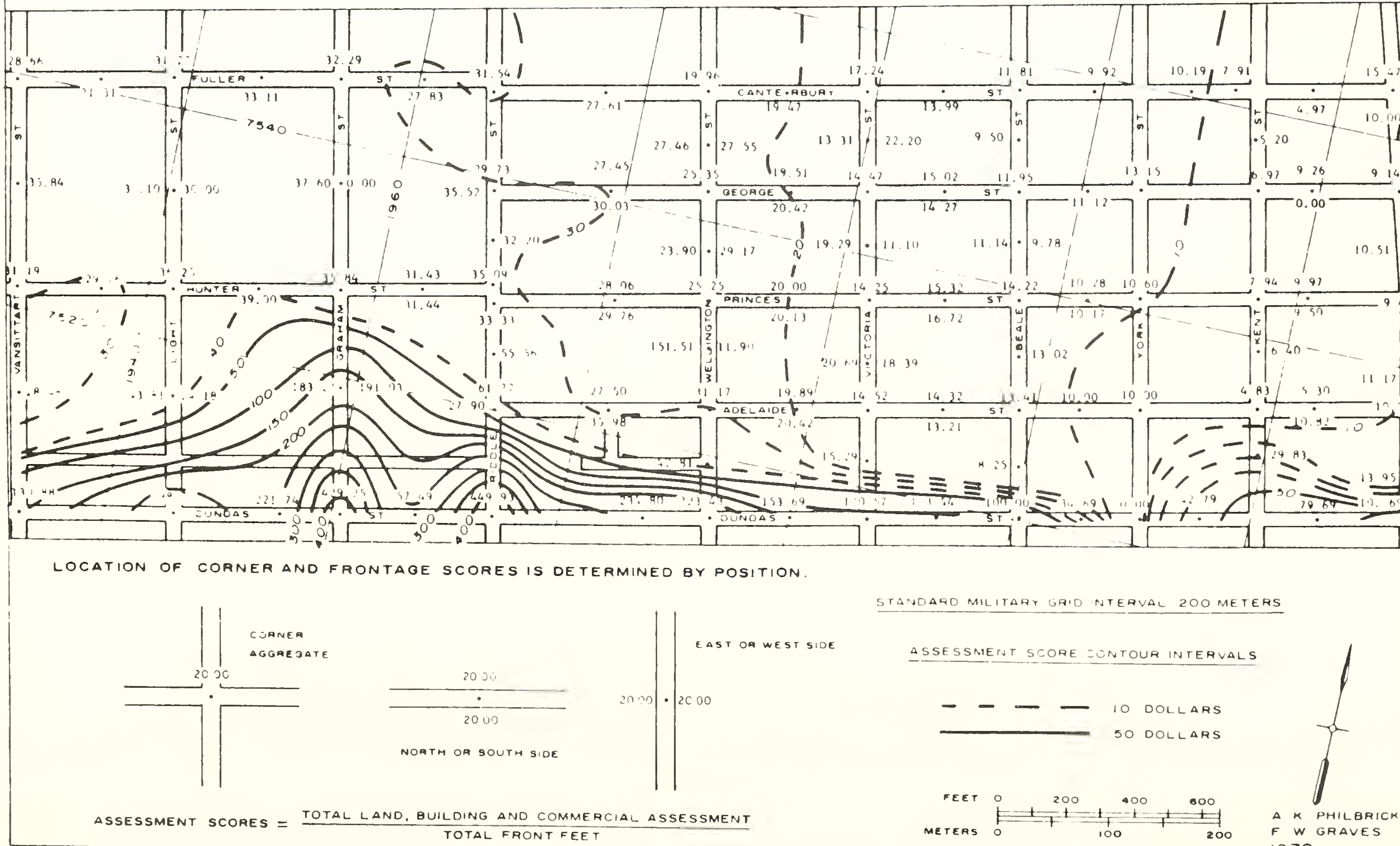
REPRINTED FROM FARM LEVEL INVESTIGATION IN AGRICULTURAL GEOGRAPHY M.J. TROUGHTON, 1970



ASSESSMENT PER FRONT FOOT FOR CORNERS AND FRONTAGE UNITS

FOR

CENTRAL WOODSTOCK, 1968



A P P E N D I C E S

APPENDIX "A"

SCALE CONVERSIONS

Method of Calculation	$\frac{RFD}{12}$	$\frac{RFD}{792}$	$\frac{63,360}{RFD}$	$\frac{(RFD)^2}{6,272,640}$	$\frac{Acres/sq.\ in.}{640}$
Representative fraction (scale)	Feet per inch	Chains per inch	Inches per mile	Acres per square inch	Square miles per square inch
(A)	(B)	(C)	(D)	(E)	(F)
1: 7,920	660.00	10.00	8.00	10.00	0.0156
1: 8,000	666.67	10.10	7.92	10.20	0.0159
1: 8,400	700.00	10.61	7.54	11.25	0.0176
1: 9,000	750.00	11.36	7.04	12.91	0.0202
1: 9,600	800.00	12.12	6.60	14.69	0.0230
1:10,000	833.33	12.63	6.34	15.94	0.0249
1:10,800	900.00	13.64	5.87	18.60	0.0291
1:12,000	1,000.00	15.15	5.28	22.96	0.0359
1:13,200	1,100.00	16.67	4.80	27.78	0.0434
1:14,400	1,200.00	18.18	4.40	33.06	0.0517
1:15,000	1,250.00	18.94	4.22	35.87	0.0560
1:15,600	1,300.00	19.70	4.06	38.80	0.0606
1:15,840	1,320.00	20.00	4.00	40.00	0.0625
1:16,000	1,333.33	20.20	3.96	40.81	0.0638
1:16,800	1,400.00	21.21	3.77	45.00	0.0703
1:18,000	1,500.00	22.73	3.52	51.65	0.0807
1:19,200	1,600.00	24.24	3.30	58.77	0.0918
1:20,000	1,666.67	25.25	3.17	63.77	0.0996
1:20,400	1,700.00	25.76	3.11	66.34	0.1037
1:21,120	1,760.00	26.67	3.00	71.11	0.1111
1:21,600	1,800.00	27.27	2.93	74.38	0.1162
1:22,800	1,900.00	28.79	2.78	82.87	0.1295
1:24,000	2,000.00	30.30	2.64	91.83	0.1435
1:25,000	2,083.33	31.57	2.53	99.64	0.1557
1:31,680	2,640.00	40.00	2.00	160.00	0.2500

Conversions for scales not shown can be made from the relationships listed at the top of each column. Using the scale of 1:7,920 as an example (col. A, line 1), the number of feet per inch is computed by dividing the representative fraction denominator (RFD) by 12 (no. of inches per foot). Thus, 7,920 - 12 = 660 feet per inch (col. B). By dividing the RFD by 792 (inches per chain), the number of chains per inch is derived (col. C). Other calculations can be made similarly. Under column D, the figure 63,360 represents the number of inches in one mile; in column E, the figure 6,272,640 is the number of square inches in one acre; and in column F, the number 640 is acres per square mile.

APPENDIX "B"

AERIAL SURVEYORS - OTTAWA

Canadian Association of Aerial Surveyors 46 Elgin	232-8770
General Photogrammetric Services Ltd. 40 Bently	825-1874
Terra Surveys Ltd. 1312 Bank	731-9571
Pathfinder Air Surveys Ltd. 3363 Carling	828-2213
Shaw Photogrammetric Services Ltd. 30 Thorncliffe Place	829-3801
Space Optic Ltd. 320 Moodie Drive	829-5200
Spartan Aero Limited 380 Hunt Club Road	822-0121
Continental Mapping Corporation Limited P.O. Box 11037, Station "H"	

AERIAL SURVEYORS - TORONTO

Canadian Aero Service Ltd. 1252 Lawrence Ave. East	445-9716
Canadian Aero Service Ltd. Division of Litton Industries 36 Toronto Street	366-2233
International Mapping Services Ltd. 209 Adelaide East	363-5016
Lockwood Survey Corp Ltd. 1450 O'Connor Drive	755-1141
Spartan Air Services Ltd. 101 Richmond West	364-1401
Western Photogrammetry Ltd. 5889 Airport Road	677=6651

Schedule 1

Item	Column 1	Column 2
	Zone	Reference Meridian
1	8	73° 30′
2	9	76° 30′
3	10	79° 30′
4	11	82° 30′
5	12	81° 00′
6	13	84° 00′
7	14	87° 00′
8	15	90° 00′
9	16	93° 00′
10	17	96 00′

O Reg 301/69, Sched 1.

REGULATION 809

under The Surveys Act

THE ONTARIO CO-ORDINATE SYSTEM

1. In this regulation,

(*a*) "co-ordinate survey" means a survey made for the purpose of establishing the location of points on the surface of the earth by geographic or grid co-ordinates;

(*b*) "System" means the Ontario Co-ordinate System. O. Reg. 301/69, s. 1.

2.—(1) There is hereby established a system of co-ordinate surveys to be known as the Ontario Co-ordinate System.

(2) The System is a universal transverse Mercator projection modified to a 3 degree zone of the Clarke spheroid of 1866. O. Reg. 301/69, s. 2.

3.—(1) For the purposes of identification of co-ordinates of points in the System, Ontario is divided into ten zones that are numbered 8 to 17, both inclusive.

(2) The reference meridian for a zone mentioned in an item of column 1 of Schedule 1 is the meridian of longitude shown opposite thereto in column 2 of the item and is the Y-axis of the zone.

(3) The X-axis of a zone is the equator.

(4) Subject to subsection 5, a zone is the part of Ontario lying within the limits of a 3 degree zone on the Clarke spheroid of 1866.

(5) Zones 10 and 11 do not extend north of and zones 12 and 13 do not extend south of a line described as follows:

Beginning at the intersection of the boundary between Ontario and Quebec with meridian of longitude 79° 30', thence south along that meridian to parallel of latitude 47° 00', thence west along that parallel to meridian of longitude 80° 15', thence south along that meridian to parallel of latitude 46° 00', thence west along that parallel to its intersection with the boundary between Canada and the United States of America. O. Reg. 301/69, s. 3.

4. In the System, the scale factor at a reference meridian is 0.99990. O. Reg. 301/69, s. 4.

5. In the System, the co-ordinates of a point,

(*a*) depend upon and shall be adjusted to the North American datum, 1927 adjustment;

(*b*) shall be expressed in feet and decimals of a foot; and

(*c*) shall be expressed as two terms, the first being the X or easting co-ordinate and the second being the Y or northing co-ordinate. O. Reg. 301/69, s. 5.

6. In the System, the origin of co-ordinates in a zone is the intersection of the reference meridian of the zone and the equator and has a northing co-ordinate of zero feet and an easting co-ordinate of 1,000,000 feet. O. Reg. 301/69, s. 6.

7. In the System, the direction of a line shall be expressed as a grid azimuth. O. Reg. 301/69, s. 7.

8.—(1) In the System, in converting metres to feet the number of metres shall be divided by 0.3048000.

(2) In the System, in converting feet to metres the number of feet shall be divided by 3.2808399. O. Reg. 301/69, s. 8.

ASSIGNMENT LESSON IV - EDITION TEN

The accompanying photograph was taken on the shores of Lake Ontario. Surveying was originally done in a single front township format with lot sizes of 20 chains X 100 chains. Road allowances were established at every second lot. Since then much of the area has been developed into an urban community.

Please return the air photograph with the rest of the assignment.

1. Determine the scale of the photograph and show your calculations.

2. Indicate NORTH on the air photograph and give reasons for your choice.

3. How does relief displacement on air photographs cause problems for the interpreter?

4. What is the probable wind direction when this photograph was taken?

5. If one was unaware of the distance between road allowances but knew that the focal length of the camera was 10 inches and the airplane flew at 14,000 ft. A.S.L., what is the distance between harbour breakwaters (marked on photograph)?

6. Indicate on the photograph:

   (a) an oil storage area

   (b) an overpass

   (c) a golf course

   (d) a trucking and warehouse establishment

   (e) a small creek

   (f) an orchard

   (g) a high school

   (h) a railway siding

   (i) a baseball diamond

   (j) a townhouse complex

A
B